Universidade de Aveiro Departamento de Comunicação e Arte
Ano 2019

Cláudia Pedro Ortet

Gamificação e Cicloturismo Sénior: Design de uma *App* para a Comunidade miOne

Gamification and Senior Cyclo-tourism: Designing an App for the miOne Community

Universidade de Aveiro Departamento de Comunicação e Arte
Ano 2019

Cláudia Pedro Ortet

Gamificação e Cicloturismo Sénior: Design de uma *App* para a Comunidade miOne

Gamification and Senior Cyclo-tourism: Designing an App for the miOne Community

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Comunicação Multimédia, realizada sob a orientação científica da Doutora Ana Isabel Barreto Furtado Franco de Albuquerque Veloso, Professora Auxiliar do Departamento de Comunicação e Arte da Universidade de Aveiro, e sob a coorientação da Doutora Liliana Filipa Vale Costa, Investigadora do Departamento de Comunicação e Arte da Universidade de Aveiro.

Trabalho realizado no âmbito do projeto SEDUCE 2.0 – Utilização da Comunicação e da Informação na comunidade online miOne pelo cidadão sénior.

Apoio financeiro da FCT e do FSE no âmbito do III Quadro Comunitário de Apoio projeto SEDUCE 2.0 nr. POCI-01-0145-FEDER-031696.

Dedico este trabalho à minha mãe pelo aconselhamento e apoio infindáveis.

o júri

presidente

Prof. Doutor Pedro Miguel dos Santos Beça Pereira
Professor Auxiliar do Departamento de Comunicação e Arte da Universidade de Aveiro

Prof. Doutor José Carlos Baptista da Mota
Professor Auxiliar do Departamento de Ciências Sociais, Políticas e do Território da Universidade de Aveiro

Prof. Doutora Ana Isabel Barreto Furtado Franco de Albuquerque Veloso
Professora Auxiliar do Departamento de Comunicação e Arte da Universidade de Aveiro

agradecimentos

O maior agradecimento será sempre à minha mãe que, para além de ter sido graças a ela que foi possível seguir este caminho, me apoia incondicionalmente, incentivando-me a seguir os meus sonhos e ser alguém com foco, ambição e determinação.

À orientadora Dr. Ana Isabel Veloso, não só pela orientação, mas também pela motivação e confiança depositadas em mim, permitindo-me arriscar e acreditar que os meus pensamentos idealísticos são exequíveis e têm valor. Considero-me afortunada em ter tido a oportunidade de trabalhar com a Prof. Ana.

À coorientadora Dr. Liliana Vale Costa, cujo a disponibilidade, entrega, minuciosidade, conhecimento e supervisão foram inspiradoras e me incitaram a querer ser cada vez melhor. Sem dúvida que para mim será sempre uma referência e um exemplo a seguir.

Ao Fernando Duarte, pelos ensinamentos e acompanhamento no ciclismo, assim como pela participação e ajuda nas voltas de bicicleta de reconhecimento e teste.

Aos participantes da Universidade Sénior da Gafanha da Nazaré, Universidade Sénior de Esmoriz e ciclistas de diferentes países. Sem eles o estudo seria impossível de se realizar.

Por fim, à minha família, amigos, colegas e professores que sempre estiveram presentes em momentos importantes da minha vida e que me levaram a este momento.

acknowledgments

The greatest acknowledgment will always be to my mother. Besides being thanks to her that it was possible to follow this path, supports me unconditionally, encouraging me to follow my dreams and be someone with focus, ambition and determination.

To my supervisor Dr. Ana Isabel Veloso, not only for her guidance, but also for the motivation and trust placed in me, allowing me to risk and believe that my idealistic thoughts are feasible and have value. I am fortunate to have had the opportunity to work with her.

To the co-coordinator Dr. Liliana Vale Costa, whose availability, dedication, thoroughness, knowledge and supervision were inspiring and stimulated me to want to be better. No doubt that for me she will always be a reference and a role-model.

To Fernando Duarte, for his teachings and companionship in cycling, as well as for the participation and aid in bicycle rides for recognition and test.

To the participants of the University of Third Age of Gafanha of Nazaré, University of Third Age of Esmoriz and cyclists from different countries. Without them the study would not be possible to materialize.

Finally, to my family, friends, colleagues and professors who have always been present at important moments in my life and that have led me to this moment.

palavras-chave

Cidadão Sénior, Gamificação, Motivação, Cicloturismo.

resumo

Com o contínuo crescimento do envelhecimento da população, tem havido um interesse progressivo na área da gerontecnologia. No caso específico da indústria dos jogos digitais, os cidadãos seniores fazem parte de um grupo de consumidores com poder de compra e tempo livre, pelo que é essencial compreender o papel dos jogos digitais no seu bem-estar e atender às suas necessidades e preferências. No entanto, continua a prevalecer uma falta de informação e de produtos que abordam o exercício físico nas inter-relações entre o ciclismo, turismo, jogos, gamificação e cidadãos seniores. O objetivo desta investigação é compreender o uso de estratégias de gamificação para motivar os cidadãos seniores a aderirem ao cicloturismo.

Esta dissertação reporta a utilização do Método de Investigação de Desenvolvimento, tendo como base os seguintes métodos: grupos de discussão, *eye-tracking* e entrevistas. Um total de 46 participantes (7 participantes de grupos de discussão, 8 participantes de *eye-tracking* e 31 ciclistas entrevistados) foram envolvidos nesta investigação. Após a revisão da literatura, trabalho relacionado, e os resultados obtidos de cada método, procedeu-se ao *co-design* e prototipagem uma *app* de cicloturismo designada *Jizo*.

Os resultados indicam que certas técnicas e elementos da gamificação podem desencadear as motivações dos cidadãos seniores para o cicloturismo, além de serem partes essenciais e integrantes de um aplicativo deste contexto. Os elementos destacados foram as relações sociais, progressão, desafios, competição, feedback e recompensas, na medida em que eles têm um papel importante na pré, *in loco* e na pós-experiência. Estes dados suportam a ideia da capacidade da gamificação para motivar o cicloturismo sénior.

keywords Senior Citizens, Gamification, Motivation, Cyclo-tourism.

abstract

As the aging population continues to grow, there has been an increasing interest in the subject of gerontechnology. In the specific case of the digital game industry, senior citizens are becoming better consumers due to their purchasing power and free time, so it is important to focus on the role of games to their wellbeing and meet their needs and preferences. However, there is a general lack of information and products that address physical exercise in the interrelationship of cycling, tourism, games, gamification and senior citizens. The aim of this research is to understand the way gamification interventions can motivate senior citizens to adhere to cyclo-tourism.

This dissertation reports on the use of the Development Research Method, deploying a broad array of methods, including focus groups, eye-tracking and interviews. A total of 46 participants (7 focus group participants, 8 participants in eye-tracking and 31 cyclists' interviewees) were involved in this research. Based on the literature review, related work and the insights from each method, a cyclo-tourism digital app entitled *Jizo* was co-designed and prototyped.

Findings indicate that certain gamification techniques and elements can trigger senior citizens' motivations towards cyclo-tourism, being essential integrative parts of a digital app in this context. The elements highlighted were social relationships, progression, challenges, competition, feedback and rewards, having an important role in pre-, in loco and post- experience. These data support the view on gamification capability to motivate senior cyclo-tourism.

Table of Contents

List of Tables

List of Figures

List of Abbreviations and Acronyms

ACSM	American College of Sports Medicine
AI	Artificial Intelligence
APA	American Psychological Association
APP	Application
AR	Augmented Reality
ARCS	Attention, Relevance, Confidence and Satisfaction.
AXE	Anticipated eXperience Evaluation
Bike	Bicycle
BPM	Beat per minute
CD-ROM	Compact Disc Read-Only Memory
CV	*Curriculum Vitae*
Demo	Demonstration
DMC	Dynamics, Mechanics, Components
ECT	European Cyclists' Federation
e.g.	*Exempli gratia* – For example
ETC	European Travel Commission
FG	Focus Group
FOMO	Fear of Missing Out
GPS	Global Positioning System
GT	Grounded Theory
Gym	Gymnasium
HCI	Human-Computer Interaction
Hex	Hexadecimal
ICT	Information and Communication Technologies

i.e.	*Id est* – That is
INE	Instituto Nacional de Estatística
INPI	Instituto Nacional da Propriedade Industrial
IOS	iPhone Operating System
KM	Kilometres
KOM	King of the Mountain
Logo	Logotype
MAC	Macintosh
MDA	Mechanics, Dynamics, Aesthetics
NPC	Non-Player Character
PAR	Participatory Action Research
PC	Personal Computer
PD	Participatory Design
PICTIVE	Plastic Interface for Collaborative Exploration Technology through Video
pm	*Post merīdiem*
POI	Point of Interest
QOM	Queen of the Mountain
RGB	Red Green Blue
RPM	Revolutions per Minute
SDT	Self-Determination Theory
SEDUCE	Senior Citizen Use of Communication and Information in miOne community
SWOT	Strengths, Weaknesses, Opportunities, Threats
UCD	User-Centred Design
UI	User Interface

UK	United Kingdom
UNWTO	World Tourism Organization
USA	United States of America
UX	User eXperience
VR	Virtual Reality
WHO	World Health Organization

This page is left intentionally blank

Introduction

Considering today's sedentarism in senior citizens that is associated with an increased risk of mortality (Rezende et al., 2014), the growth of an aging population and the prevalence of mobility and health impairments, several studies (*e.g.* Webb, 2008; Groot & Fagerström, 2010; Derboven et al., 2012) have shown a renewed interest in combining home and outdoor fitness with digital games, while engaging senior citizen's communities with digital platforms.

According to the World Health Organization (2002), a steady growth of people aged 60 and over has been observed in comparison with other age groups. It is estimated that this growth will be nearly 223% between 1970 and 2025 and a total of 1.2 billion people over the age of 60 will inhabit the world in 2025 (WHO, 2002). In Portugal, there will be 317 senior citizens per 100 youngsters by the year of 2080 (INE, 2016).

According to Pak and McLaughlin (2010, p.1), "age is an indicator of how long one has lived but is not a complete indicator of a specific individual's capabilities and limitations". The same authors suggest a number of different indicators to take into account when assessing the context of use of Information and Communication Technologies (ICT) in senior citizens: their familiarity with interface conventions and use of current digital platforms; and perceptual and cognitive changes, as farsightedness, need of glasses, hearing aids and memory challenges. Indeed, these aspects are likely to have a major effect on the success of an app, digital game or other digital platforms.

The purpose of this research is to understand the way gamification can motivate senior citizens to adhere to cyclo-tourism (*i.e.* Research Question: *"How can gamification motivate senior citizens to cyclo-tourism?*"), by recognizing and meeting their needs and preferences as gamers. The keywords 'Senior Citizens', 'Gamification', 'Motivation' and 'Cyclo-tourism' will be the impetus of this theoretical framework.

This research is supported by the SEDUCE 2.0 project[1] POCI-01-0145-FEDER-031696 (SEDUCE 2.0 - Senior Citizen Use of Communication and Information in miOne community), which has the following goals: (i) assess the impact of psychological variables and sociability on senior citizens through the use of ICT in the context of the online community[2]; and (ii) contribute

[1] www.seduce.pt (Accessed: February 2019)

[2] www.mione.pt (Accessed: 27 July 2018)

to the growing development of the online miOne community with the active participation of senior citizens. This community embodies the following functionalities: communicating tools - email service and an instant messaging service; health information; news information; games; and an area for sharing personal interests and experiences.

The Research Problem Statement

The inverting European demographic pyramid, especially the Portuguese one, illustrates the exponential growth of the aging population, in comparison with other age groups. Furthermore, senior citizens tend to often represent a vulnerable group at risk of social and digital marginalization (Marsili & Capacci, 2014).

Given the high dependence on digital platforms to perform daily actions, the current gap between senior citizens and younger groups may enlarge owing to, for example, both the age-related physiological and psychological changes and the lack of concern with the usability, accessibility and context of use in virtual environments (Zheng et al., 2013).

Differences in the usage of technology may also be dependent on such aspects as income disparities, perception of actual need to use digital platforms, products being too difficult to learn to use, among others (Olson et al., 2010; Fisk et al., 2009). Explaining the potential ICT benefits is, therefore, essential in order to increase the adherence to such products.

Two tendencies often associated with age may arise: a decline in physical exercise and a rise in the likelihood of chronic disease. Hence, the group of senior citizens is of interest to those concerned about public health (Nyman et al., 2018), and an increasingly need to re-invent strategies for sustainable active aging and healthier lifestyles is brought to the fore in public debate and social policies (Costa & Grist, 2017).

Physical exercise is an intervention with many known positive physiological and cognitive effects, since it is a strong gene modulator that affects structural and functional changes in brain plasticity, giving enormous benefits to individual's wellbeing (Mandolesi et al., 2018). Research on the use of game-based exercise interventions to encourage cognitive health in senior citizens (Anderson-Hanley et al., 2012) has suggested that the use of a stationary bike or a cybercycle exergame improves senior citizens' health, with significant benefits to the senior citizens' executive function (Anderson-Hanley et al.,2012).

Despite these cognitive benefits of physical exercise in later life, only a small fraction of senior citizens do exercise at the recommended levels (at least 30 minutes a day) (American College of Sports Medicine, 2009) and that fact has led to the proliferation of studies (*e.g.* Smith & Schoene, 2012; Barnett et al., 2013) that examine the use of exergaming technologies (Microsoft Kinect[3] and Nintendo Wii[4]), to motivate senior citizens to exercise by integrating digital game features and physical exercise activities (Lieberman, 2009).

The Research Question

A research question was formulated based on the problem statement and the quality criteria of clarity, feasibility and relevance (Quivy & Campenhoudt, 2008). The research question is:

"How can gamification motivate senior citizens to cyclo-tourism?"

A qualitative method approach was used in order to answer the research question by analysing the literature and carrying out a set of co-design techniques, focus group sessions, interviews and eye-tracking, in order to identify the main characteristics that a gamified app should have to motivate senior citizens to cyclo-tourism. The study addresses the following sub-questions:

i. *"What are the current market-oriented digital apps that address cyclo-tourism?";*

ii. *"What are the gamification elements and techniques that can be applied to a cyclo-tourism app?";*

iii. *"What are the main difficulties that senior citizens have when interacting with the games' interfaces?".*

[3] https://developer.microsoft.com/en-us/windows/kinect (Accessed: 15 November 2018)

[4] https://www.nintendo.com/wiiu/what-is-wiiu (Accessed: 15 November 2018)

The Project Aims and Goals

The aims of this research are to design a gamified app that motivates senior citizens to cyclo-tourism and identify the game features that would serve that purpose.

The main goals answered by the literature review, focus group and interviews are:

i. Study how games and gamification can motivate senior citizens to cyclo-tourism;

ii. Analyse the potential of bicycle exergames and gamified apps for senior citizens;

iii. Understand the preferences and intentions of senior citizens to play;

iv. Explore the main guidelines to create a gamified app adapted to this target audience.

The specific goals answered by the co-design session with the participants are:

i. Involve the participants in the design of a gamified app design through the use of co-design sessions;

ii. Draw up a prototype adapted to senior citizens;

iii. Test and evaluate the prototype;

iv. Understand the senior citizens' motivations to use gamified digital apps.

The specific goals answered by the eye-tracking session are:

i. Identify the senior citizens' difficulties when interacting with the digital app *Jizo*.

The Analysis Model

The analysis model is designed to organize and clarify the research-based concepts, dimensions and indicators (Quivy & Campenhoudt, 2008). It is divided into concepts that are based on the research question and its keywords, dimensions and indicators. Table 1 presents the analysis model of this research.

Table 1 - Analysis Model

Concepts	***Dimensions***	***Indicators***
Senior Citizens (*e.g.* Vaz-Serra, 1986; Demirbilek, 1999; Kalache & Keller, 2000; Antonucci, 2001; Aison et al., 2002; Llano et al., 2003)	Socio-demography	Geographic Distribution
		Social
	Aging Process	Physical Effects
		Socio-Psychological Effects
Gamification (*e.g.* Keller, 1987; Fisk et al., 2009, Deterding et al. 2011; Zichermann & Cunningham, 2011; Werbach & Hunter, 2012; Veloso & Costa, 2016; Chou, 2017)	Elements	Dynamics
		Mechanics
		Components
	Theories	ARCS Model
		Behavioural Model
		Octalysis Framework
		Self-Determination Theory
	Design	Simple Feedback
		Captions
		Interaction Keys
		Rankings
		Tutorials
Motivation (*e.g.* Maslow, 1954; Vallerand et at. 1989, 1993; Ryan & Deci, 2000a, 2000b; Taylor, 2007)	Amotivation	Absence
	Intrinsic	To Know
		To Accomplish
		To Experience Stimulation
	Extrinsic	External Regulation
		Introjected Regulation
		Identified Regulation
		Integrated Regulation
Cyclo-tourism (*e.g.* Smith & Jenner, 1997; Loverseed, 2000; Spinney, 2006; Alff, 2011; Resende & Filho, 2011; Cox, 2012)	Tourism	Senior Tourism
	Cycling	Sport Cyclo-tourist
		Punctual Cyclo-tourist

As shown in Table 1, the analysis model is divided into the concepts of 'Senior Citizens', 'Gamification', 'Motivation' and 'Cyclo-tourism' that are based on the research question "*How can gamification motivate senior citizens to cyclo-tourism?*". All these concepts are explained throughout this document, as well as its correspondent dimensions and indicators.

- Expected Results:

In this dissertation, a co-designed prototype of a gamified digital app addressed to senior citizens in a cyclo-tourism context is developed. Similarly, this study aims to demonstrate the potential of gamification to senior cyclo-tourism.

Based on the literature review, it is expected that gamification can motivate senior citizens to adhere to cyclo-tourism, because it can induce intrinsic motivation (*e.g.* increase user's satisfaction, convey optimism, ease social interaction and provide meaning) and extrinsic motivation (*e.g.* earn awards/badges or reach milestones). Tourism and cycling are activities that senior citizens tend to like and engage, not doing it more often due to age-related inabilities (Patterson, 2007; Pucher & Buehler, 2008) and a set of constraints (*e.g.* bicycle maintenance, performance tracking, social relationships, training, route design, etc.). Therefore, a gamified app can be the solution to this known but unexplored problem.

The Research Method

This study follows a development research method owing to the fact that there is almost non-existent studies or reports that cover the case of gamification in cyclo-tourism, especially addressed to senior citizens.

The research strategy is divided into three key steps of development, as shown in Figure 1 (Maren, 1996).

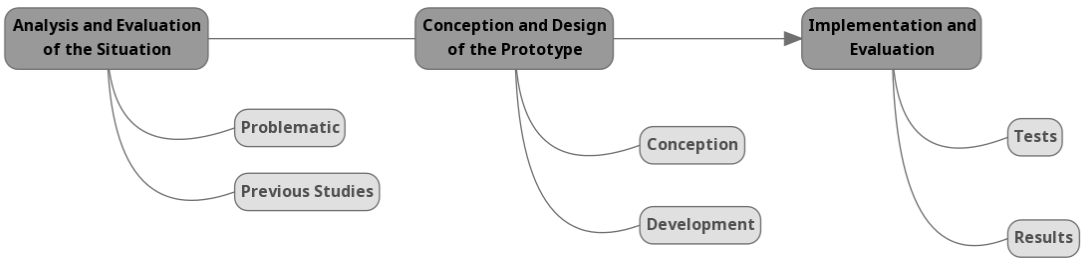

Figure 1 - Research Development Method. Adapted from Maren (1996)

The first step entitled **"Analysis and Evaluation of the Situation**" refers to the analysis and evaluation of the research problem, based on the literature review, analysis model, focus groups and interviews. In the literature review process, information was gathered by searching the concepts of the analysis model (*i.e.* senior citizens, gamification, motivation and cyclo-tourism) in scientific data bases (*e.g.* Scopus[5], Google Scholar[6], Web of Science[7]). The most used digital applications in both cycling activities and tourism were studied in order to identify their key functional requirements and understand its relevance in the cyclo-tourism context and suitability to the target group;

The second step entitled **"Conception and Design of the Prototype"** starts with problem-solving led by the researcher, in which there is an attempt to understand senior citizens' context and familiarity with digital devices and interface conventions. Both the researcher and participants generate game ideas and, subsequently, participate equally in the co-design process. The co-design sessions embody such strategies as brainstorming, scenario building, semi-structured interviews, sketching and collage. Consequently, the principle "design by users and for users" provide better results with higher success rates than only relying on the designer's role (Demirbilek & Demirkan, 2004);

Finally, the third step entitled **"Implementation and Evaluation"** is devoted to the implementation of the prototype that was based on the literature review, focus group and interviews' input, and participants' evaluation, using a questionnaire and eye-tracking. A demo of a gamified app, which was played and tested by the participants is presented, while the results are collected. In this step, both the researcher and participants collaborate in the design process, using participant observations and co-design techniques. The end-user's comments were taken into consideration for future improvements of the prototype that was build.

My Personal Motivations

I always wanted to take risks and explore new worlds, so, in my bachelor's degree in Languages and Business Relations, I had the chance to study new languages, such as Chinese. It

[5] https://www.scopus.com/home.uri (Accessed: July 2018)

[6] https://scholar.google.pt/ (Accessed: July 2018)

[7] https://www.webofknowledge.com/ (Accessed: July 2018)

was very challenging, but not enough. Although my background was in Science, Languages and Marketing, I decided to take a Master's degree in Multimedia Communication in order to use what I've learned but also to embark on something more enthusiastic and inspirational.

During my Master, I have learned how to create digital games and gamified apps with attractive narratives, in order to meet the context and motivations of senior citizens. I also participated in the SEDUCE 2.0 research project and it caught my attention and interest in this field.

In this research, I had the opportunity to spread my wings of creativity and take steps into the unknown, which led to this project, something new and unexplored – Gamification and Senior Cyclo-tourism.

The Dissertation Structure

This dissertation is mainly divided into six chapters. The document begins by introducing the research theme. It will then go on to the theoretical framework and related work, such as exergames and apps for cycling and tourism.

The first chapter entitled "Senior Citizens" covers the social-demographic changes in society, the physiological and psychological effects of the aging process and leisure activities for active aging.

The second chapter introduces the concept of Gamification: the elements, theories and the design process. It also addresses the topic of Motivation, embodying the concepts of Intrinsic Motivation, Extrinsic Motivation and Amotivation.

The third chapter introduces the Related Work. Several studies and applications of gamification in tourism, cycling exergames and gamification in cycling are discussed.

The fourth chapter focuses on Senior Tourism and Cyclo-tourism. The concept of Tourism is covered, as well as cycling in tourism and cyclo-tourism organizations.

The fifth chapter is devoted to the Empirical Research and it is divided into the description of the method, the techniques and tools used for data collection, contextualization of the

research, the conceptualization process, the design, implementation and evaluation process, data coding and analysis.

The sixth chapter deals with the results that come from the co-design sessions, the prototype and recommendations for designing a gamified digital app for senior cyclo-tourism, based on the outcomes of usability tests with the end-users, obtained by using eye-tracking and questionnaires.

Lastly, the dissertation ends with the conclusion, answering the research question and reflecting on the prototype future improvements.

This document was fully written in English. Data collection instruments were translated from Portuguese to English and all ethical concerns have been considered during this research.

This page is left intentionally blank

1. Senior Citizens

Even though there is a lack of consensus in the definition of the chronological dimension of aging, the age of retirement is 66 years and 5 months in Portugal (Economias, 2019). The World Health Organization (WHO, 2002) considers the age of 60 years and over to define senior citizens. However, this research will not consider that age for senior citizens, but rather the age of 55 years and over, since it is common to find people of such age at the Universities of Third Age.

This chapter presents the socio-demographic changes in society and senior citizens' physiological and psychological effects. The concept of Active Aging is enlightened and the leisure activities for active aging are covered.

1.1. Socio-Demographic Changes in Society

Decreasing fertility rates and increasing longevity will ensure the continued aging of the world's population. In fact, fertility rates are estimated to considerably drop, being below the replacement level in 120 countries by the year of 2025 (WHO, 2002), whereas population aging is expected to prevail in developed regions of the world.

In 2002, nine out of ten countries with more than ten million inhabitants and the largest proportion of older people were in Europe. Furthermore, slight variations are expected by 2025 when people aged 60 and over will be nearly one-third of the population in such developed countries as Italy, Japan and Germany, among other European countries (Figure 2).

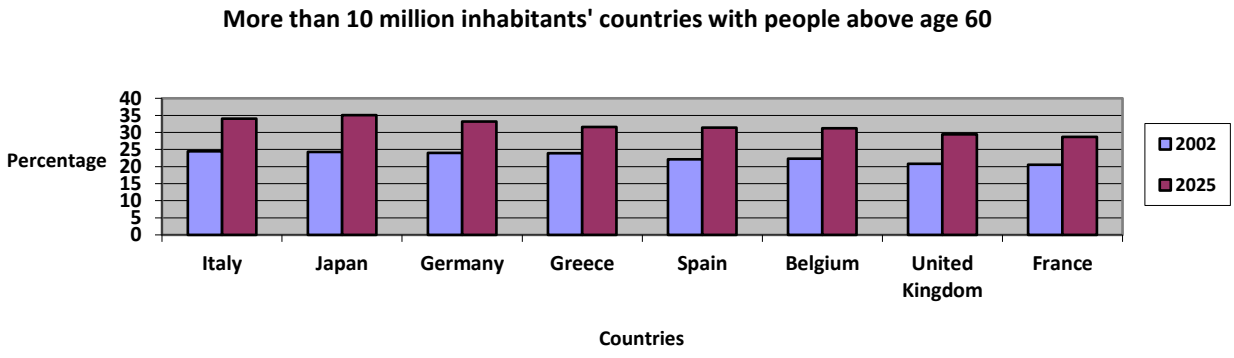

Figure 2 - Percentage of countries with more than 10 million inhabitants (in 2002) with people aged over 60 and comparison with its estimation for 2025. Adapted from "Active Ageing: A Policy Framework" (WHO, 2002)

In fact, almost 400 million people, aged over 60 years old lived in developed countries in 2002. By 2025, a growth of approximately 400 million to 840 million is expected, being a representation of 70 percent of senior citizens of the global population. In terms of regions, Asia is the continent where over half of the world's oldest people live, and, because of that, this country will continue to grow the most (Figure 3).

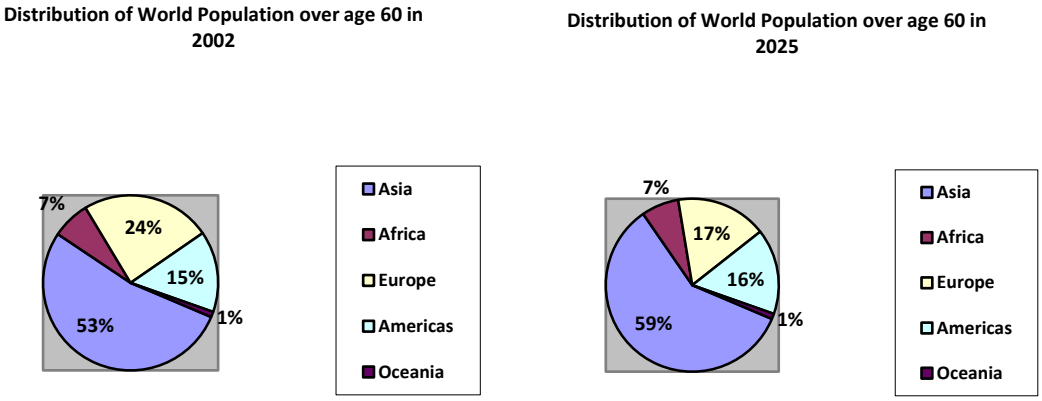

Figure 3 - Distribution of World Population over age 60 by region, 2002 and 2025. Adapted from "Active Ageing: A Policy Framework" (WHO, 2002)

According to Kalache and Keller (2000), there is a significant difference between developed and developing countries, in which the developed ones can prosper in terms of resources and wealth, in comparison with developing countries.

Alongside with the demographic changes, social support tends to decrease with age as well as contact with friends (Shaw et al., 2007). Indeed, senior citizens can experience different types of social losses, such as: loss of others by death and distance; social support by isolation; and loss of power by financial and/or knowledge decline (Kaplan & Berkman, 2016).

Friendship networks also dwindle throughout life (Kalmijn, 2003). Socio-economic status seems to have an impact on social networks and satisfaction with the support received (Antonucci, 2001). In other words, there is a greater chance of perception of isolation and depression in senior citizens as successive losses occur in their networks.

1.2. Physiological and Psychological Effects

Aging is a personal trajectory built throughout the years, dependent on our choices, decisions and results, which may affect the individual's physical and psychological well-being (WHO, 2002). This trajectory is a process that, from the physiological perspective, is not necessarily analogous to the advancement of chronological age, presenting considerable variation from individual to individual (Llano et al., 2003).

A brief overview of the physiological and psychological effects of the aging process is provided below.

- Physiological Effects

During the aging process, physical changes are likely to occur in the decrease in acuity of the five sense organs, with distinct focus on vision and hearing, and the decline in the function of important organs, specifically the heart, lungs and kidneys, muscle mass, hormone levels and brain (Ramadan, 2009). Although some studies (*e.g.* Harada et al., 2013) have shown that the normal aging process is usually accompanied by a decrease in certain cognitive and neuro-motor functions; other studies (*e.g.* Vance et al., 2010; Berardi et al., 2017) draw our attention to Neuroplasticity, that refers to the changes that occur in the nervous system when exposed to new experiences (Guerrinha, 2019), being the basis of memory formation and learning and having a restorage potential of neural injuries or damages (Meirelles et al., 2017).

Given the aforementioned physiological effects, tasks involving motor coordination, reaction time, short-term memory, and abstract or complex conceptualization may be challenging (Aison et al., 2002). When considering physical activity and mobility, the following aspects should also be taken into account: arterial stiffening, gradual loss of elastic properties of connective tissues, increase in the amount of fat, decreased muscle strength, and decreased ability to coordinate skills (Pak & McLaughlin, 2010; Nigam et al., 2012).

- Psychological Effects

Senior citizens are a group that tend to have difficulty in a set of cognitive activities: (a) understanding complex or long messages; (b) reasoning tasks involving logical analysis, pattern

recognition and information selection; and (c) performing tasks involving time and speed (Vaz-Serra, 1986). Consequently, this cognitive decline may lead to depressive symptoms (Forsell et al., 1997).

Even though the physiological effects can be more noticeable at a naked eye, sometimes the psychological effects have a great impact (Bond et al., 2008). According to Figueroba (2017), attentional capacities (sustained, divided and selective attention), the different components of memory, intelligence (both fluid and crystallized) and creativity are the most notable aspects in the aging process.

In terms of the senior citizens' attention, a decline in the functioning of the attentional process occurs, but not in an equal way. In other words, in sustained attention (*i.e.* fixed attentional focus for a relatively long period of time), senior citizens tend to be less precise at the start of the tasks in comparison to younger age groups, even though they do not necessarily have a lower success rate. Relative to divided attention (*i.e.* alternated attentional focus), the level of difficulty in being attentive is proportional to the individual performance. In contrast, selective attention is likely to be maintained during the aging process, only being affected when tasks are difficult or when there is a need to ignore significant amount of irrelevant information.

Although the deterioration of memory is not always associated to old age directly but through the appearance of cognitive deficits of pathological intensity, working memory is likely to worsen with age, especially at the age of 70. This is commonly associated with difficulties in dealing with the attention problems.

Regarding crystallized intelligence (*i.e.* accumulated and progressive knowledge), it generally continues to increase throughout the aging process. By contrast, fluid intelligence (*i.e.* intelligence associated with the efficiency of neural transmissions and other biological factors) tends to deteriorate.

Lastly, creativity varies from individual to individual and it is likely to be trained and/or improved, even though some people are more creative than others. However, among those who are not very creative, this capacity tends to decrease as people get old.

1.3. Active Aging

According to the World Health Organization (2002, p.12), Active Aging can be defined as "(…) the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age.".

The word "active" refers not only to the functional capability of being physically active, but also embodies the individuals' willingness to participate in other activities (*i.e.* social, economic, cultural, spiritual and civic matters). In fact, senior citizens who are already retired from work and those who live with some disabilities and/or illnesses can remain active contributors to society (WHO, 2002).

To summarize, active aging aims to extend quality of life and healthy life expectancy for all people as they age, with no exceptions. As senior citizens become more active in their daily lives and disability rates drop, the population become better prepared to cope with aging (Demirbilek, 1999).

1.3.1. Leisure Activities for Active Aging

The World Health Organization (2002, p. 12) defines Health as "the physical, mental and social well-being." Based on that definition the physical dimension is important for a good health, both the cognitive and social dimensions. Indeed, physical exercise and ICT use can increase cognitive training and social interactions, which are crucial in determining the adoption of healthier lifestyles.

- Physical Exercise

During the aging process, some physical limitations appear, which may affect the senior citizens' autonomy. In fact, difficulties in locomotion, control, postural adaptation and orientation are some of the critical factors in the reduction of individuals' autonomy (Shepard, 2002).

According to Rikli and Jones (2013), physical exercise is understood to be the ability of performing daily tasks autonomously and independently without the onset of fatigue and when

doing it regularly, it can delay functional deteriorations and prevent chronic diseases. For example, regular moderate physical activity can reduce the risk of cardiac death by 20 to 25 percent among people with heart diseases (Merz and Forrester, 1997).

Mazo and her colleagues (2008) reported that physical exercise can improve health-related quality of life, physical and psychological well-being. According to the same authors, the practice of physical exercise and the level of individuals' life satisfaction are interrelated.

The American College of Sports Medicine (ACSM, 2009), the world's largest organization of sports medicine and science, draws our attention to the fact that senior citizens' physical exercise programs should include resistance, strength, balance, and flexibility exercises. Physical capacity is essential for the individuals' health, as well as for the accomplishment of everyday tasks and the practice of physical exercise (Riebe et al., 2018).

It is worth noting that doing a physical exercise does not have to be difficult, exhausting or boring. Every opportunity that increases mobility, even only for a few minutes a day, is a healthy way to at least get started (Ribeiro & Paúl, 2011).

In the study "Older adults motivating factors and barriers to exercise to prevent falls" (Groot & Fagerström, 2010), the results showed that motivating factors to adhere to recommended physical exercise were perceived prospects of staying independent, maintaining current health status and improving physical balance and the ability to walk. In the opposite, barriers reduced health status, while leading to lack of motivation and unpleasant experience during exercise group sessions.

Having discussed the importance of Physical Exercise, the next sections will cover the role of Information and Communication Technologies in Physical Exercise.

- Information and Communication Technologies in Aging

One of the major concerns in an increasingly aging society is the overdependence in ICT and the subsequent challenges faced by senior citizens owing to the limitations of the Human aging process and the lack of access to digital platforms and understanding of interface conventions (Pasqualotti et al., 2007).

The subject of age-related technology has been popular in research over the past few years (Zheng et al., 2013) and the findings have highlighted that a gap between younger and older generations is still present, regarding the fact that the latter did not have previous access to ICT in their daily life, when compared to younger generations. In the same vein, senior citizens experience more problems with ICT than younger adults do (Zheng et al., 2013).

Learning how to use a computer and/or Internet is considered to be a new skill, being that a cognitive challenging endeavour. Additionally, technological activities are very demanding in terms of cognitive functions, such as speed in information processing, selective memory and memory. By encouraging senior citizens to use computers and the Internet, their cognitive abilities, autonomy and engagement in interpersonal relations and productive activity in performing everyday tasks may be stimulated (Zheng et al. 2013).

As highlighted by Nierling and Domínguez-Rué (2016) in Chapter "Motives of the Elderly for the Use of Technology in their Daily Lives", senior citizens perceive the use of modern technology as an important opportunity to improve their technical skills and the next session clarifies the way digitally mediated strategies can be used to motivate Physical Exercise.

- <u>The role of ICT in motivation to Physical Exercise</u>

The practice of Physical Exercise does not have to be limited to the traditional form, commonly known as outdoors or indoors exercises at gym, and with equipment (Corre, 2018). In fact, technology in a modern society makes a valuable contribution to the practice of Physical Exercise in the comfort of the individual's home. Kinect[8], for example, is a technology that makes possible to use interactive games to practice different sports, being entitled 'Exergames' (Smith & Schoene, 2012).

According to a report from Microsoft[9] (2014), doctors are using Kinect to help heart attack patients to recover from their incapacities, throughout the use of training exercises, immediate feedback and encouragement. Even at some hospitals, doctors are recommending patients to use Kinect games on Xbox 360. The reason is not only because it is a way of distracting, but also

[8] https://developer.microsoft.com/en-us/windows/kinect (Accessed: 15 November 2018)

[9] https://www.microsoft.com (Accessed: 15 November 2018)

because it enables data analysis from patients' pain and respective movements relative to their training activities and improvements (Tsukayama, 2013).

Maillot and her colleagues (2012) conducted a test using digital games supported by Kinect to see if there were any improvements in senior citizens' health. In this study, 32 senior citizens were divided into two groups: 16 participants in the control group, with no previous contact with the game and 16 participants in the experimental test group. Throughout the experiment, two participants gave up (one from each group), leaving 15 participants in each group. The physical impact of the training program was measured by heart rate per minute and by the demonstrated effort, whereas the neurological impact was evaluated throughout the use of both accomplishment and visuospatial tasks and processing speed. This study was extended for 14 weeks, including pre-test and post-test, when the participants were subjected to a battery of neurological and physical exams to obtain the outcomes of the game-playing activity. The results demonstrated significant physical improvements in the subjects of the experimental group.

2. Gamification and Motivation

Playing digital games has become increasingly popular amongst senior citizens in the last two decades (Zheng et al., 2013). Although research into playing in a later life phase is growing with a focus on the domain of Interaction Design (*e.g.* Dewsbury et al., 2006), gerontological research is still rare (De Schutter, 2011).

Some studies (*e.g.* Drew & Waters, 1986; Clark et al., 1987) showed that playing digital games may have a positive effect on autonomous functions in later life, self-esteem and reaction time. For example, Goldstein and his colleagues (1997) found that non-institutionalized senior citizens who played Super Tetris nearly five hours per week, for five weeks, improved significantly their reaction time and increased their well-being.

Another randomized trial study (Torres, 2018) showed that casual digital games can improve senior citizens' cognitive functioning and maintenance of self-concept and quality of life.

Similarly, other studies (Gamberini et al., 2009; Whitlock et al., 2012; Loos, 2014), have demonstrated that games can, indeed, train the learner's memory, improve cognitive functioning and positively influence the individual's self-concept and quality of life.

Moreover, digital games can even encourage social interaction and dialogue between older and younger generations (Derboven et al., 2012). As benefits, games are also suggested to foster intergenerational interactions by contributing to individual wellbeing, prosocial behaviours, and sharing of knowledge; providing a communal activity and balancing both users' challenges and their skills (Costa & Veloso, 2016).

Considering the potential benefits from playing games for senior citizens, it is important to understand the game elements and strategies that can motivate them to adhere to the game-playing activity. Therefore, the following sections clarify the gamification's definition, game design techniques and elements, non-game contexts and behavioural design.

2.1. The Concept of Gamification

According to Maslow (1954) and Vianna and his colleagues (2013), people may have a great deal of interest in intangible goods, such as respect and status, and these forms of motivation

are the same principles that are part of the basic concept of gamification (Werbach & Hunter, 2012).

Gamification can be defined as the use of elements and techniques of game design in the context of a non-game environment, attempting to motivate the user to carry out an ordinary activity (Deterding et al., 2011). This technique is used in different fields from the entertainment industry to education and/or health. The dominant idea is to take the base of digital games, and to implement it in situations of the real world, frequently with the intention of motivating specific behaviours within the gamified scenario (Sailer et al., 2017).

Although its popularity, Zichermann and Cunningham (2011) remind us to the fact that gamifying a product, or a service, does not mean simply giving virtual badges and insignias every time the user performs an action. Gamification usually involves a plan in order to motivate the players to perform a set of tasks with pleasure, seducing them to a certain measurable goal. Digital games are, thus, powerful artefacts, being a trigger to certain actions and initiatives (Zichermann & Cunningham, 2011).

Gamification is also a persuasive technology that can influence the end-user's behaviour by activating their motives via game-design elements (Petkov et al., 2011). Basically, gamification explores the individual's empathy in order to meet their intrinsic and extrinsic motivations (McGonigal, 2012). McGonigal (2012) identifies the following use on games of intrinsic motivation:

- Increase in user satisfaction: The end-user's progress results from attainable personal goals and immediate feedback, giving a perceived sense of high individual performance;
- Conveyance of optimism: Gamification enables self-determination and the feeling of accomplishment;
- Facilitation of social interaction: Gamification enables social exchange and/or competition because, normally, the user enters to a community;
- Provision of meaning: Gamification fosters daily life challenges, helping to overcome individual's limitations.

In terms of extrinsic motivation, gamification has also an important role by encouraging changes on behaviours through points, badges, leaderboards and other formal game elements that are further explained in the subchapter Game Design Techniques and Elements.

To summarize, gamification refers to service design similar to digital games, typically with the purpose of changing user behaviour. (Huotari & Hamari, 2012). The concept of gamification (game + modification) has evolved over the years, and although it has been a taken for granted concept, there is not a consensus towards its meaning. Currently, the use of gamification as service design has emphasized the following characteristics: (a) use of game design techniques; (b) use of games elements; and (c) application in non-game contexts (Werbach & Hunter, 2012).

2.2. Game Design Techniques and Elements

In any gamifying process, the game elements are indispensable pieces in the design and development of a gamified activity. Deterding and his colleagues (2011) consider game elements as a fundamental part of the gamification concept and according to these authors, game elements, not necessarily all and cumulatively, play a preponderant role for the development of a game and game-playing experience.

These elements are the foundation of all gamified systems and have their origin in the MDA framework (Mechanics, Dynamics and Aesthetics), developed by Hunicke, LeBlanc and Zubek (2004), that form the core of a gamified design and the playful experience, both from the point of view of the designer and the end-user.

The MDA framework was revisited by Werbach and Hunter (2012) and according to the authors, game elements tools can be taken from the game's core, being considered regular patterns, and used in business and/or other non-game contexts. These authors also proposed a framework entitled as The Game Element Hierarchy or DMC Pyramid which encompasses different categories of game elements, as shown in Figure 4.

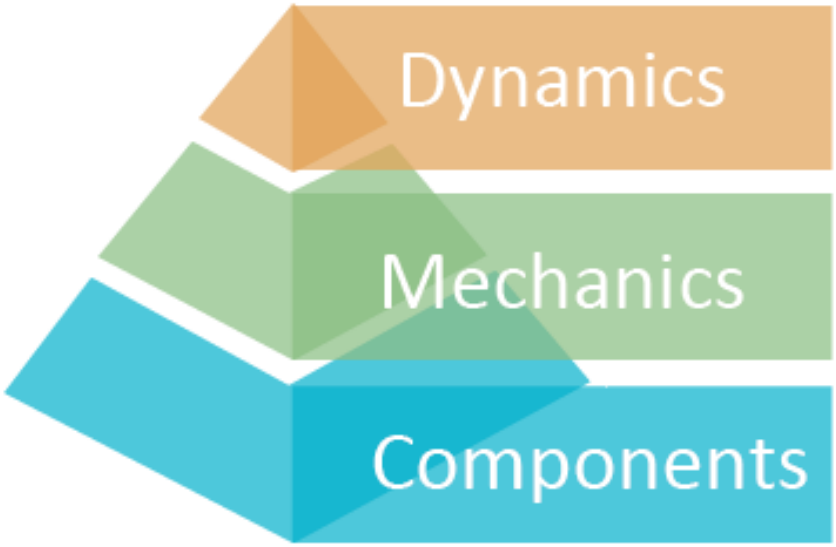

Figure 4 - The DMC Pyramid. Adapted from "For the Win: How Game Thinking Can Revolutionize Your Business" (Werbach & Hunter, 2012)

The structure of the pyramid is divided into three levels, in which a progression principle is applied (*i.e.* the lower levels constitute the path to access the elements of a higher level), ranging from the abstract (the dynamics) to the concrete (the components) and being interlinked with the mechanics:

i. The lowest level of the pyramid refers to the Game **Components** that include achievements, avatars, badges, boss fights, collections, combat, unlocking content, gifting, rankings, levels, points, quests, social chart, teams and virtual goods;

ii. **Mechanics** are related with challenges, chances, cooperation and competition, feedback, acquisition of resources, rewards, transactions, turns and win states;

iii. **Dynamics** embody narrative, relationships, emotions, constraints and progression.

2.2.1. Components

The Game Components are the basis of Game Elements, because they are the particular way of performing high level actions represented by the Dynamics and Game Mechanics (Werbach & Hunter, 2012).

The authors Werbach and Hunter (2012) categorize the following elements as Game Components:

- Achievements: Reward the player when completed a set of specific tasks;
- Avatar: Visual representation of the player character;
- Badges: Visual representation of the accomplishments achieved in the game;
- Boss Fights: These fights translating into more difficult challenges usually occur between players and NPC (*i.e.* non-player characters), that usually happens at the end of the level;
- Collections: Set of items or emblems that can be collected;
- Combat: This action involves guiding and defeating opponents in fights and challenges;
- Unlocking Content: Games can offer the possibility of unlocking access to restricted content in the game, if the requirements, goals or missions are met;
- Gifting: This action refers to the possibility of offering virtual items or coins to other players;
- Rankings: These are ordered lists of players, according to their scores;
- Levels: Game levels translate the player's performance in the game, having an impact on their progress;
- Points: Numerical representation of the player's performance in the game, and, as a rule, the points and levels are intertwined;
- Quests: These are predefined challenges and objectives, which once achieved, are translated into rewards;
- Social Chart: This is the visual representation of the social network of players;
- Teams: Groups of players that work together in order to achieve a common goal;
- Virtual Goods: These are objects and items that have meaning for their users, given their role in the virtual world. Sometimes players are willing to spend virtual and/or real currency to access to such goods.

2.2.2. Mechanics

Game Mechanics are defined as a set of rules and techniques used, individually or together, as building blocks to gamify something (*e.g.* a website or an app), motivate the end-user (Deterding et al., 2011) and manage the users' performance with incentives, feedback and rewards.

Werbach and Hunter (2012) highlight that Game Mechanics are the responsible elements for the user's actions associated to a gamified experience. These actions can be the following: competing, cooperating, rewarding, transacting, challenging, among others. Thus, the game mechanics produce a significant response from the player (Zichermann & Cunningham, 2011).

Game Mechanics embody the following elements (Werbach & Hunter 2012):

- Challenges: The game sets goals for the player to achieve;
- Chances: User's actions are goal-oriented, creating a sense of uncertainty and surprise. Therefore, the luck factor is also considered, which means that not everything is decided by the player's ability;
- Cooperation and Competition: Players can work together to achieve certain goals or, on the contrary, be opponents in which only one will be a winner;
- Feedback: This feature enables the players to check their performance during game-playing, fostering a sense of progression and help, if applicable, in decision-making;
- Acquisition of Resources: Players may collect or purchase additional items associated to their achievements and winning/victory conditions;
- Rewards: Benefits obtained from the accomplishment of some objectives or certain achievements;
- Transactions: Transaction can involve buying and selling or exchanging something with other players in the game, directly or through intermediaries;
- Turns: Players' participation can be sequential and alternate. However, there are many real-time games, in which there are no turns;
- Win States: State that defines the victory or defeat condition of a player or a team.

2.2.3. Dynamics

Werbach and Hunter (2012) point out that Game Dynamics are at the top-level of conceptual game elements or gamified approach. Game Dynamics undergoes evolutions to meet the players' needs, desires and motivations.

Gamification Dynamics are the types of behaviour that players adopt in their experience, which are based on how they use the selected game mechanics (Robson et al., 2015) and mechanics related to the game behaviour and strategic interactions (Camerer, 2014).

Since this concept is based on the way players adopt the Mechanics (Robson et al, 2015), all these aspects must be considered and managed (Werbach & Hunter, 2012), in order to lead to the success of a gamified system. According to Zichermann and Cunningham (2011), Game Dynamics are related to how the players interact and engage with the system, whereas Game Mechanics are the tools used to generate the gameplay experience. Game Mechanics are, therefore, a complement to Game Dynamics.

Werbach and Hunter (2012) categorize the following elements as Game Dynamics:

- Narrative: The structure that brings parts of the game or the gamified system together into a coherent whole;
- Relationships: Common social dynamics are very important for the game playing experience, since people have and feel the need to interact with others, generating a feeling of camaraderie, status and altruism;
- Emotions: The way users feel and express the emotions are driven by the game;
- Constraints: Limitations of the game;
- Progression: It does not specifically require levels and points but should give the user the feeling that they are having the opportunity to evolve.

2.3. Non-game Contexts

Gamification has a similarity to serious games, in the way that it uses elements of games for other purposes than entertainment. In Sawyer and Smith's taxonomy of serious games (2008),

games can be divided into: (a) games for health; (b) advergames; (c) games for training; (d) games for education; (e) games for science and research; (f) production; and (g) games as work. Deterding and his colleagues (2011) also considered that it is possible to apply gamification to other contexts (*e.g.* gamification for training, health, news and tourism) (Deterding et al., 2011).

There are several examples of the application of gamification in education (*e.g.* Domínguez et al., 2013) – *i.e.* Duolingo[10]; health industry (*e.g.* Cafazzo et al., 2012) – *i.e.* Nike +[11]; marketing and business training (*e.g.* Barata et al., 2013); sustainable behaviour (*e.g.* Negruşa et al., 2015) and tourism industry (*e.g.* Xu et al., 2014) – *i.e.* Foursquare[12].

2.4. Motivation and Behavioural Design

Concurrently, designers and design theorists are exploring how consumer products could influence user's behaviours towards a reduction in its use and impacts (Rodriguez & Boks, 2005). Design is not only a reflective activity, but also an emotional and intuitive process, and as overstated by Damásio (2004), emotions and feelings are fundamental for rational thinking and decision-making.

Most people are internally and externally motivated to meet their needs, regarding the fact that an impulse often leads people to do something in order to accomplish a task. Whereas an amotivated or unmotivated person is not inspired to act, a motivated person usually has the energy and will-power to achieve own goals (Ryan & Deci, 2000a).

According to Taylor (2007), there is a difference between the term "motive" and "motivation". When people think of "motive", normally, it suggests preconceived intentions or goals, like motive for revenge, financial reward, method acting, among others. The word "motivation" has a more positive connotation, often associated with incentives or spirited inspiration (Taylor, 2007).

[10] https://www.duolingo.com/ (Accessed: December 2018)

[11] https://play.google.com/store/apps/details?id=com.nike.plusgps&hl=en (Accessed: December 2018)

[12] https://play.google.com/store/apps/details?id=com.joelapenna.foursquared&hl=pt (Accessed: December 2018)

In Self-Determination Theory (SDT), the authors Deci and Ryan (1985) distinguish between different types of motivation that are categorized into different goals or reasons. The most basic distinction is between intrinsic motivation, which is associated to do something because of its exciting or pleasant inherently matter, and extrinsic motivation, which is associated to act in a way because it will manifest in a separable result. It is possible to define SDT as a method that uses traditional experimental approaches to Human personality and motivation. Self-Determination Theory highlight the inner resources for developing personality and self-regulating individual's behaviour (Deci & Ryan, 1985).

The Maslow Pyramid (Figure 5), which represents the hierarchy of Human needs, is a generalized theory for debating Human motivations (Maslow 1954). The fundamental levels of needs are represented at the base of the pyramid whereas the physiological needs are considered as hygienic factors, and, therefore, do not generate any motivation. On the contrary, social needs or belonging needs, esteem and self-actualization are considered as motivational factors (Teixeira, 2005).

Figure 5 – Maslow's Pyramid. Adapted from "Motivation and Personality" (Maslow, 1954)

2.4.1. Types of Motivation

Vallerand and his colleagues (1993) believed that motivation can be divided into three types:

I. Amotivation

Amotivation occurs when individuals' motivations are absent, and there is a lack of intention to act. Amotivation is a consequence from not valuing an activity (Ryan, 1995), not feeling capable to do it (Deci, 1975), or not believing on own capacity to achieve a wanted result (Seligman, 1996).

II. Intrinsic Motivation

The singularity of intrinsic motivation was firstly recognised within empirical studies of animal behaviour, where it was discovered that, even in the absenteeism of rewards, numerous animals engage in exploratory, playful and curiosity-driven behaviours (White, 1959).

An individual is intrinsically motivated when (s)he does not do an activity for other purposes (*e.g.* external pressures or awards) than meeting their personal satisfactions (Ryan & Deci, 2000a). This type of motivation is natural and significant in cognitive, social, and physical development, because people can evolve their skills and deepen their self-knowledge when they are acting for their own interests.

Intrinsic motivation varies from person to person and it is dependent on their personality trait and own interests.

Vallerand and his colleagues (1989) have divided intrinsic motivation into the following three:

i. **Intrinsic motivation to know**: When people engage in an activity because of the pleasure and satisfaction inherent to the activity. This type of intrinsic motivation is shown in gratification from learning, discovering and acknowledging new things;

ii. **Intrinsic motivation to accomplish**: When people engage in an activity because of the pleasure and satisfaction they will have while creating or trying to exceed themselves;

iii. **Intrinsic motivation to experience stimulation**: When people engage in an activity because of the stimulating sensations connected with it.

III. Extrinsic Motivation

Although intrinsic motivation is clearly a central type of motivation, most of the activities people do can be extrinsically motivated. In that way, extrinsic motivation refers to doing an activity by its instrumental value. Extrinsic motivated behaviours are, thus, assumed to reach an end state that is separated from the actual behaviour.

Ryan and Deci (2000b) subdivide extrinsic motivation into four types:

i. **Extrinsic motivation of external regulation**: When people's acts are done to reach a positive outcome (*e.g.* to earn money) or to avoid a negative end (*e.g.* to dodge punishment);

ii. **Extrinsic motivation of introjection**: When people start to personify the reasons for their behaviours;

iii. **Extrinsic motivation of identification**: When the reason to engage in an activity is embedded, in a way that the activity is considered valuable by each person and the behaviour is controlled through the identification of the activity;

iv. **Extrinsic motivation of integration**: When the coherence with choice and self-structures are achieved.

Most of the theories used in gamification interrelate motivational and the gamification context. Considering that motivation plays an important role in gamification to change behaviours, the following topics presents some theories relevant to this research:

2.4.2. Gamification and Motivation Theories

2.4.2.1. ARCS Model

The ARCS Model is a four-factor model proposed by John Keller (1987) that comprises the following: (i) Attention, (ii) Relevance, (iii) Confidence and (iv) Satisfaction. Even though this model is focused on instructional design, the same elements can be applied to gamification and game-based learning. The key elements are listed below:

i. Attention is important to grab the person's interest to a certain content. People's attention can be done by **perceptual arousal** (*i.e.* gaining attention through the means of relatable events, by using incongruity or the element of surprise); **inquiry arousal** (*i.e.* stimulating curiosity, problems-solving or role-playing); and **variability** (*i.e.* varying periodically the delivery method periodically);

ii. Relevance should take into account: **goal orientation** (*i.e.* lead the person towards the goal by explaining and describing the importance of reaching it); **motives match** (*i.e.* matching instructional goals with the individual's goals can encourage power, achievement, affiliation or risk taking); **familiarity** (*i.e.* demonstrate how the acquired knowledge is related to the already owned); and **modelling** the learning results to new knowledge.

iii. Confidence is likely to occur when people feel they can learn and achieve success or tend to be more motivated to proceed the task. The initial requirements and expectations towards a task are necessary to be pre-determined, so that people can estimate the amount of time and effort they need to put into it. Additionally, small wins also can help to build people's confidence, sense of control, deadline schedule and competitiveness.

iv. Satisfaction is achieved when people feel that the task they are performing has value and is worth of effort. Providing encouraging feedback is, thus, a strategy that may lead self-motivation.

In general, the ARCS model unravels that individual's intrinsic motivations can be fostered by grabbing their attention, through the use of a challenge and scaffolding. Rewarding small wins is also another strategy to foster people's confidence and satisfaction.

2.4.2.2. Behavioural Model

According to Fogg (2009), a behaviour model is needed in order to persuade changes in behaviours through digitally mediated experiences. This model is easy to perceive and widely used in the game context (Fogg, 2009). In this way, the model presupposes the existence of three necessary factors underlying all Human behaviour:

i. Motivation: In Human behaviour, a sense of pleasure, pain, hope, fear, acceptance or rejection are anticipated with the use of games (*i.e.* the person is highly motivated);

ii. Ability: Such factors as time, money, physical and psychological effort, social deviance and non-routine activities may affect Human behaviour (*i.e.* the person considers that the behaviour is simple);

iii. Trigger: Human behaviour relies on the use of reminders or notifications associated to individuals' action (*i.e.* the person is cued, reminded and called to action).

These three factors must be presented and occur at the same moment to effectively engage people and, therefore, one may suppose that the core of a successful gamification project is to figure out the right motivations and triggers, not relying only in the technology use (Fogg, 2009).

2.4.2.3. Octalysis Framework

Octalysis is a gamification framework (Figure 6) created by Chou (2017), in which the game industry is intertwined with the Human-Focused Design principle. Octalysis is presented in an octagon shape with 8 Core Drives representing each side. On the left side, there are the left-brain core drives, being associated to logic, calculations and ownerships; whereas on the right-side there are the right-brain core drives, being linked to creativity, self-expression and social aspects.

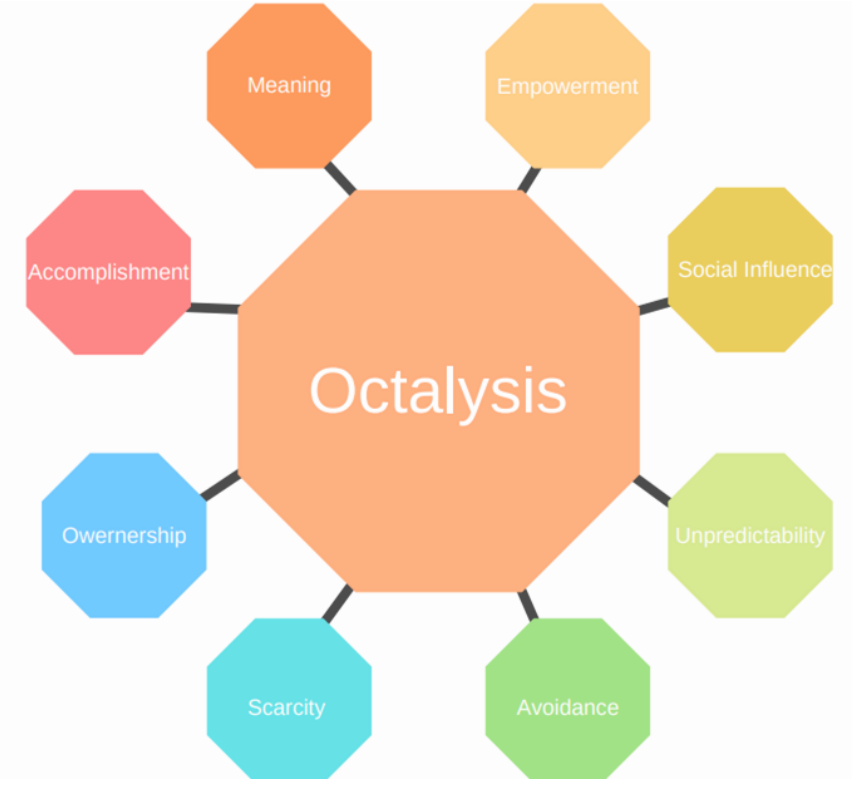

Figure 6 – Octalysis. Adapted from Actionable Gamification (Chou, 2017)

In the author's point of view, games are fun because they appeal to certain core drives of the players, motivating them towards certain activities. Even though Chou (2017) believes that there is a ninth hidden Core Drive that he called "Sensations", everything that the player does is based on one or more of the eight Core Drives:

i. Epic Meaning and Calling give players the feeling that they are chosen, special or lucky to do something (*i.e.* narrative, elitism, humanity hero, revealed heart, beginners' luck, free lunch, destiny child, creationist);

ii. Development and Accomplishment allow players to develop skills and complete challenges in exchange for a reward (*i.e.* status points, badges, rewards, leaderboard, progress bar, quests lists, dessert oasis, high five, crowning, anticipation parade, aura effect, step-by-step overlay tutorial, boss fights);

iii. Empowerment of Creativity and Feedback engage users in the creative process to try different combinations and figure things out (*i.e.* milestones unlocks, real-time control, evergreen control, instant feedback, boosters, blank fills, plant pickers, poison pickers);

iv. Ownership and Possession motivate players to customize characters, accumulate and own virtual goods (*e.g.* virtual currency) or complete a collection (*i.e.* exchangeable points, virtual goods, build from scratch, Alfred effect, collection sets, avatar, protection, recruiter burden, monitor attachment);

v. Social Influence and Relatedness include social elements (*e.g.* companionship, mentorship, acceptance, social responses and competition) to stimulate player's interaction (*i.e.* friending, social treasure/gifting, seesaw bump, group quests, tout flags, brag button, water cooler, conformity anchors, mentorship, social prod);

vi. Scarcity and Impatience is related to the players' desire to have something they cannot have at the moment (*e.g.* come tomorrow to unlock this feature), making game aspects available to a limited number of players or restricted in time (*i.e.* appointment dynamics, magnetic caps, dangling, prize pacing, options pacing, last mile drive, count drown timer, torture breaks, moats, the big burn);

vii. Unpredictability and Curiosity drive players' curiosity of wanting to find what will happen throughout the activity, because when people do not know what will

happen, the brain is engaged and will think about it often (*i.e.* glowing choice, mini quests, visual storytelling, easter eggs, random rewards; obvious wonder, rolling rewards, evolver UI, sudden rewards, oracle effect);

viii. Loss and Avoidance add risks (*e.g.* loosing progress) to make players avoid certain behaviour or to act immediately to not loose opportunities (*i.e.* sunk cost prison, progress loss, rightful heritage, evanescence opportunity, status quo sloth, scarlet letter, visual grave, FOMO punch).

2.4.2.4. Self-Determination Theory (SDT)

Self-Determination Theory is a macro-theory, which explains Human motivation to perform a task or activity (*e.g.* sports, religion, education, work, healthcare). Indeed, self-determination has been applied to the context of digital games (*e.g.* Rigby & Ryan, 2011) and associated to self-motivation (Deci & Vansteenkiste, 2004). According to Deterding (2011), SDT is an appropriate theoretical foundation for gamification and Ryan and his colleagues (2006) suggest that the individual's external environment should be in accordance with the individual, in order to encourage proactivity and own desire to grow. In general, this theory presents a set of factors interrelated with intrinsic and/or extrinsic motivation (Ryan et al., 2006)

According to Pink (2018), intrinsic motivation refers to the individual motivation, in which a person performs a certain action simply because (s)he finds it rewarding, enjoyable, fun and exciting. Although this type of motivation is important, most of the tasks performed by people seem to not be intrinsically motivated (Ryan & Deci, 2000a) and, therefore, extrinsic motivations are likely to overpass this limitation.

Pink (2018) states that in terms of extrinsic motivation, it is triggered by rewards associated to the individuals' actions. He emphasizes that although these extrinsic motivating factors are important, they will have little impact when the threshold is reached (*i.e.* when extrinsic motivations reach a limit). Once this threshold is reached, the intrinsic motivators become more important.

In SDT, the social environment supports the following three basic needs (Kapp, 2012):

i. Autonomy: Users need to feel autonomous in their decisions and have control over their actions in order to be motivated;

ii. Competence: Competition and collaboration in game challenges are encouraged to enable scaffolding and acquisition of new skills;

iii. Relatedness: This characteristic represents the feeling of being connected to others. This connection can be with real people or even with virtual personalities generated by the computer within the game. One of the requirements is that the game enables social interaction.

In a research study examining SDT and gameplay (Ryan et al., 2006), findings have revealed that perceived in-game autonomy and competence were associated with game enjoyment, preferences, and changes in well-being. Furthermore, competence and autonomy were related to the intuitive nature of game controls and the sense of immersion participants felt in their game-play experience (Ryan et al., 2006).

To sum up, gamification theories are a relevant aspect to consider when designing a gamification strategy to affect the individual's attraction to an activity, motivation and behaviour change.

2.5. Designing for Senior Citizens

According to Gerling and his colleagues (2012), senior citizens' engagement with digital games has a positive impact on their emotional and physical wellbeing. As such, designing games as assistive environments should be customizable (adaptive); and maintain (assist), increase or improve (rehabilitate) the individuals' capabilities (Veloso & Costa, 2016).

Although senior citizens are receptive to new technologies (Zheng et al., 2013), their adherence to digital games is dependent on how interesting a game is for them. Most digital games are aimed at young individuals with high cognitive and motor abilities and game mechanics focus on high-precision movements that simply are not within the reach of senior citizens. Therefore, they tend to take more time to perform the same tasks as younger generations (Fisk et al., 2009).

Gerling and his colleagues (2012) also referred that interfaces should be multimodal due to an age-related decrease in motor skills. An example is that while active senior citizens may still be able to use regular game pads, institutionalized senior citizens may have more difficulties in

holding the controller and pressing small buttons. Additionally, the complexity of input sequences should be meaningfully reduced by having into account the decrease in senior citizens' abilities (*e.g.* short-term memory and attention process).

In this situation, probable setbacks with multiple players' input (*e.g.* performing complex point-and-click operations) should be taken into consideration. Furthermore, the graphics of the user interface must be adapted to meet the needs of senior citizens (*e.g.* visual game element size, font size, high contrast, among others) and different types of feedback (*e.g.* visual, auditory or haptic output) (Gerling et al., 2012).

Basically, it is important having into consideration the following suggestions (Dewsbury et al., 2006; Fisk et al., 2009; Gerling et al., 2012; Terra & Veloso, 2014):

- The game interface should be simple and intuitive so that senior citizens can identify and execute it;
- Provide easy to remember information;
- Interfaces should include different types of feedback (*e.g.* visual, written, and auditory);
- Do not introduce gameplay that requires a very high level of physical dexterity;
- Provide users with the ability to customize interaction keys;
- Add captions for all in-game audios;
- Simulate scenarios in which the seriousness of the problem is presented and inform about the change benefits;
- Visually differentiate the game elements;
- Add colour options to colour blind;
- Do not introduce time or speed limits as a gameplay challenge;
- The presentation of the score should be simple and easy to understand;
- Build in-game tutorials.

Gamification can be a strategy to add game design elements to the environment, which contributes to its change and may affect motivational and psychological user experiences

3. Cyclo-tourism

In order to understand cyclo-tourism, it is important to understand the concepts of tourism and senior tourism, the use of ICT in cycling and identify a number of cyclo-tourism organizations.

3.1. Tourism

Reaching a consensus on the definition of tourism is extremely difficult, which can be explained by being such a complex and multifaceted activity. Of the many definitions, the most widely used and universally accepted definition is proposed by the World Tourism Organization (UNWTO, 2008) that refers to tourism as the set of activities that people do during their vacation and stay in places outside where they live for a certain period of time, providing that it does not exceed one year, with the purpose of leisure (*i.e.* cultural tourism, visits to family and friends, vacations, sports, meetings, missions, business tourism, conferences); among other reasons (*i.e.* study, health) that do not imply the exercise of a remunerated activity in the visited place.

Tourism has become one of the most dynamic worldwide activities (*i.e.* social, cultural and economic), with faster economic growths while connecting people (Rastegaeva & Kazakov, 2016). It also plays a crucial role for both developed and developing countries, having an impact on indirect and induced employment (UNWTO, 2018).

According to Filipe (2009), tourism is important due to its multifunctionality associated with the consumer's impulses, and thus exercising the following functions:

- Recreational function: There is a concentration of places characterized by a strong tourist activity, which is not always a positive aspect. This fact may cause an imbalance in the regions' development, especially in rural areas where there is a lower concentration;

- Patrimonial function: Discovery of natural and cultural patrimony attractions and activities are likely to attract urban consumers;

- Pedagogical function: Tourists seek knowledge and learn more about the visited place;

- Social function: Tourism can generate new social ties and cultivate a relation of proximity between the visitors and local residents.

3.1.1. Senior Tourism

For the development of the tourism market and tourism products, it is important to identify new demographic challenges and the transformation in the structure of society. Indeed, the age cohorts of 50 to 55 years old and 60 to 65 years old have been an important segment to address in the tourism industry, given its significant proportion in total population (Loverseed, 2000).

Senior citizens represent an age group with a steady growth and many of them have a physical and health condition and a high propensity to travel, as some of these people whether they are retired, by choice or not, eventually start to develop a second career or their own business (Loverseed, 2000). Furthermore, Smith and Jenner (1997) ascertain that senior citizens aged between 50- and 64 years old tend to have great economic power because most people in this age group have the highest amount of income from their professional careers. Hence, segmenting the market into the group of senior citizens is relevant owing to the fact that the group aged 55 and over has more characteristics in common with the ones aged 65- and 75-year old, rather than 45- or 35-year old group (Smith & Jenner, 1997).

In tourism, senior citizens differ from younger tourists in the following characteristics: (i) distribution and frequency of tourism activities throughout the year; and (ii) use of a significant part of their income in leisure and tourism activities.

Data from the European Travel Commission study (ETC, 1994) on the distribution of international travel by senior European tourists has revealed that whereas all tourists made more than 50% of their trips during high season (*i.e.* July and August), senior tourists distributed their holiday trips throughout the year. However, senior tourism has been less seasonal than the total tourism market due to socio-economic aspects, namely greater freedom from work and lower family responsibilities (ETC, 1994). Their preference in off-pack travel tourism is influenced by the possibility of having a holiday with greater tranquillity and at cheaper prices.

According to Aln and his colleagues, senior tourists also have a greater power of consumption of leisure and tourism products *vis-a-vis* younger tourists, mostly because they usually have the highest domestic income of all age groups (Aln et al., 2012). This consumption

power can stem from a monthly retirement pension, income from savings, private insurance, capital investment, among others (Smith & Jenner, 1997).

In general, the group of newly retired senior citizens is very attractive to tourism marketing operators as they additionally have enough health and vitality to consume innovative products related with adventure activities (Patterson, 2006), and, thus, targeting this age group should be considered as an important business opportunity that also overpasses the problem of the effects of seasonality on a tourism activity.

3.2. Cycling in tourism

Cyclo-tourism, or Cycle Tourism, is an unexplored sector with a great sustainability potential in rural areas (Gazzola et al., 2018). Although riding a bicycle has been regarded as a physical exercise activity intertwined with the health and fitness sector, its application in mobility, transports and tourism sector has also an important role (Cox, 2012).

Cyclo-tourism can be defined as any cycling activity during holidays for more than a day. The use of the bicycle is, indeed, an essential part of the journey (Resende & Filho, 2011). Cyclo-tourists tend to be also environmentally conscious (Sebastianelli, 2013), in other words, cyclo-tourists usually do not use a car on their trips; and they are also likely to spend less energy and water, producing less garbage and having less impact on fauna and flora than other types of rural tourism (Gazzola et al., 2018).

Before the actual bicycle appeared, dandy-horses were used as vehicles that allowed adventurous individuals to travel long distances, as shown in Figure 7. According to Alff (2011), this vehicle moved through the pilot, who pushed it with his/her own feet, properly working on flat terrain; however, requiring an increased effort in climbing. In 1820, a dandy-horse was firstly used to travel through European countries.

Figure 7 – First Dandy-horse. Retrieved November 2018 from https://www.sueddeutsche.de/auto/rundes-jubilaeum-200-jahre-fahrrad-so-feiert-deutschland-das-jubilaeum-1.3312588

The dandy-horse was greatly improved in the mid-1870s by installing a set of pedals on the front wheel of the vehicle, making it possible for the rider to make longer distances in a shorter time. This evolution in the dandy-horse, named penny-farthing because of the resemblance of its wheels to the largest and smaller coin size, as shown in Figure 8. It became the first bicycle used for the practice of leisure activities, which consequently led to cyclo-tourism (Mortal Journey, 2011).

Figure 8 - Penny-Farthing. Retrieved November 2018 from **https://www.mortaljourney.com/2011/03/all-trends/penny-farthing-bicycle-and-the-history-of-the-bicycle**

In 1878, the Bicycle Touring Club in Britain was born, derived from the use of the bicycle for leisure and recreation activities. This club originated the still existing Cyclists Touring Club, which is to be considered the oldest organization in the world relative to bicycles.

Today's cyclo-tourism differs from cyclo-tourism in the last century, regarding the fact that technological development has facilitated and improved bicycle use, leading to enormous facilities for cycling practitioners and improving bicycles and bike products in the market. Such advancements have led to the evolution of bicycles and diversity of types of bicycles according to the context of use (*e.g.* mountain, road, track, electric, among others), development of bicycle routes and equipment used by cyclo-tourists.

There is, however, little consensus about what cyclo-tourism means from the racing cyclists' perspective, given that cyclo-tourism has historically been in contradiction to the view of cycling as sport, but its existence as a spectatorship activity (Cox, 2012). Meanwhile, cycling is an embodied and kinaesthetic experience, in which Spinney (2006) points out that the cyclo-tourist explores different places with the use of a bicycle as a means of transport and that can have a profound impact on the environment and landscape.

Cyclo-tourism also represents a niche market, despite being linked to broader mobility practices and changes in social practices produced in association with emerging discourses around sustainability and quality of life (Horton, 2006). Not only it is theoretically associated to issues of sports tourism, slow tourism and cultural identification, but it also draws the recognized intersection of leisure, recreation and tourism into policies and analyses of everyday mobility practices (McKibbin, 2015).

The association of cycling with tourism can be characterized by the following aspects: (i) use of bicycle as the means of locomotion, central to tourism; and (ii) a tradition of cycling events as tourist destinations and spectacles to be attended and observed (Gantar et al., 2012).

Based on the definition proposed by La Chaire de Tourisme de l'UQÀM (1999), a cyclo-tourist is an individual who, throughout his stay, uses the bicycle as a main resource of travel or simply for leisure purposes. Thus, it is possible to distinguish two types of cyclo-tourists, according to the main motivation of the trip:

• Sports Cyclo-tourist whose journey takes place mainly around the practice of cycling. Their main motivation is related with the use of the bicycle, and the destination is selected accordingly with their needs associated to the cycling practice;

• Punctual cyclo-tourist refers to the tourist who goes on vacation, however, throughout his/her stay, (s)he has the habit of using the bicycle as a form of leisure, either in a punctual or intermittent way.

The biggest difference that exists between these two types of cyclo-tourists relies on their motivation. Whereas the sports cyclo-tourist chooses the destination in function of the activity that (s)he intends to practice, that is, looks for destinations that provide all the necessary conditions for the use of the bicycle; the punctual cyclo-tourist prefers the comfort, looking for accommodation establishments that offer the opportunity to engage in leisure activities, such as bike rides (La Chaire de Tourisme de l'UQÀM, 1999).

As previously mentioned, cycling has undergone major technological developments over the last few years. Among the new technologies, there are the localization devices (*i.e.* GPS), helping to guide the cyclo-tourist to the destination, contrasting with those of the past centuries, where only maps were used. For this, much was due to the appearance of several organizations that were concerned with this theme.

3.2.1. Cyclo-tourism Organizations

In Europe and America, several initiatives and routes promoted by cycling associations directed towards cyclo-tourism can be easily identified. The Adventure Cycling Association is a non-profit organization whose mission is to encourage people to travel by bicycle. It was founded in 1973, entitled Bikecentennial, having the purpose of organizing a bicycle tour through the United States to celebrate the bicentennial of the country.

The Adventure Cycling Association researches and produces maps for the Adventure Cycling Route Network, one of the largest cycling routes in the world with 66,273 kilometres. Further work is being carried out to create a network of routes for the United States of America and become the largest cycle route on the planet (Adventure Cycling Association, 2015).

Another important association is the European Cyclists' Federation (ECT), founded in 1983 by 12 bicycle users. Currently, the federation has 67 members, representing more than half a million of European citizens to use the bicycle in almost 40 countries (ECT, 2014). This organisation also promotes the use of bicycle and development of national cycling organizations in Europe.

Cycling is reported as a means of transport and leisure, sustainability and health, and this view is mirrored in the federation's mission and objectives (ECT, 2014):

i. Raise the status of the bicycle and show its benefits to individuals;

ii. Consider the needs of European cyclists in terms of transport, environment, safety and health;

iii. Assist the ECF members regarding their objectives;

iv. Conduct research on issues related to cycling, transportation, the environment and safety;

v. Assist the ECF members in their bicycle-related activities, reinforcing ECF information and advice to them;

vi. Promote the exchange of information and skills among ECF members;

vii. Provide information and skills to raise awareness of specific groups, such as travel agencies that sell cycling packages, among others.

This federation is the organizer of EuroVelo[13], a single network that embodies a set of bicycle routes, interlinking Europe and attracting cyclo-tourists to experience these routes.

[13] http://www.eurovelo.com/en (Accessed: December 2018)

This page is left intentionally blank

4. Related Work

Based on the keywords of this dissertation, several projects were studied in order to understand their success and influence in the end-user. The projects are detailed in the following sections:

4.1. Gamification in Tourism

According to Jeffrey (2011), the World Travel Market Report predicts that gamification will be a major trend for the coming years in tourism. Furthermore, Xu and her colleagues (2013) add that the main motivations to play a tourism game are: (i) obtain accurate information about a destination in a pre-, during and post-experience; and (ii) be able to interact with other people. For that, combining both physical and digital spaces is important in order to merge virtual and reality in the players' mindset, selling an imaginary world of fantasy and fun (*i.e.* mixed-reality games).

REXplorer

An example of a tourism game is REXplorer from Ballagas and his colleagues (2008). This game was designed especially for tourists at Regensburg, in Germany, with the purpose of informing them about its history in a playfully experience. This mobile, pervasive and spell-casting digital game offers player encounters with spirits of historical figures that are associated with significant buildings in an urban setting. To communicate with these spirits, the player waves the mobile phone through the air, imitating the mechanism of casting a spell.

To play this game, people need to have a mobile phone with the app installed and a respective city map brochure (Figure 9). Every time the tourist reaches a building, they need to select it via app and a heartbeat vibration will start if the place has a paranormal activity to allow the player to cast the spell (Ballagas et al., 2008). According to the authors, one of the features of this game that differentiates from others is the freedom of path, choices and pace.

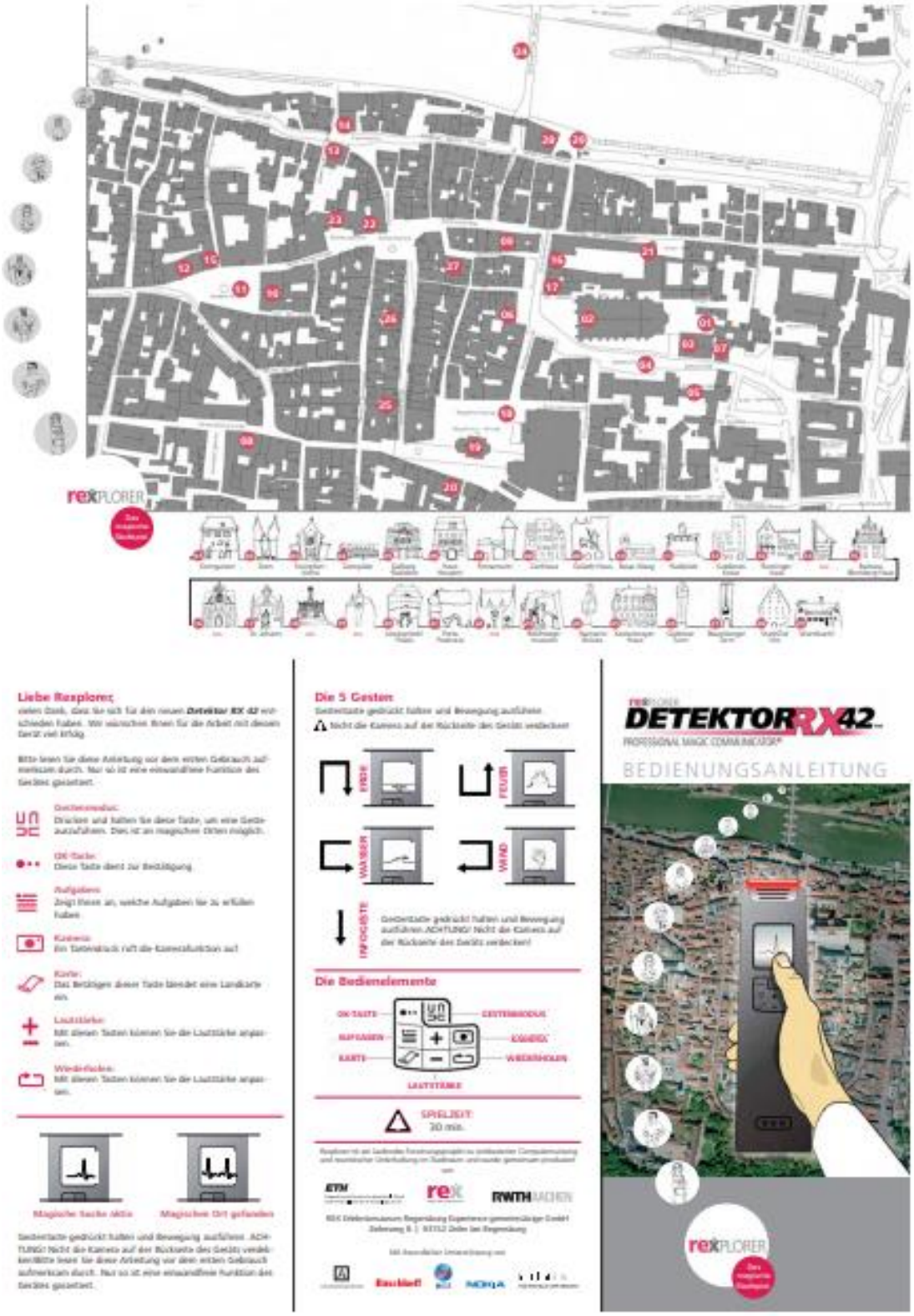

Figure 9 - REXplorer brochure, Retrieved November, 2018 from Gaming Tourism: Lessons from Evaluating REXplorer, a Pervasive Game for Tourists (Ballagas et al., 2008)

Eye Shakespeare

The English city Stratford upon Avon, hometown of Shakespeare, has developed an app entitled "Eye Shakespeare" (Figure 10). This gamified mobile app uses Augmented Reality (AR) to provide a 3D virtual Shakespeare to tourists, who introduce his birthplace, show them the place around and enables them to take a photo together with this virtual figure. Instead of traditional tour guides, this virtual figure tale telling Shakespeare stories is a different and entertaining way of touring. By using some game elements (*e.g.* reward and storytelling) it provides tourists with a fun, interactive, and engaging experience (Xu et al., 2017).

Figure 10 - Screenshots from Eye Shakespeare, Retrieved November, 2018 from http://www.shakespeare.org.uk/visit-the-houses/eye-shakespeare-app.html

These (*i.e.* REXplorer and Eye Shakespeare) are good example of digital games applied to tourism. They succeed to inform players about the history and culture of the subject (*e.g.* city or important/relevant events) in a playful manner.

4.2. Cycling Exergames

Many senior citizens report happy memories about riding a bike outdoors at a younger age but some of them have not the possibility to ride a bicycle again (Join-in Project, 2014). This may

be due to functional limitations related to age, increased road traffic or easy access to convenient motorized transportation.

Elliptical bikes can be used for exercise by senior citizens, providing a convenient way to keep fit and healthy without having to leave home or other buildings. However, cycling alone at home or indoor can be very boring, and does not resemble at all to an outdoor bike trip with a group of friends.

Exerbiking Join-in Project

In "Exerbiking" Join-in Project (2014), users are allowed to participate in multi-player online cycling trips, using an elliptical bike (Figure 11). In specific, players can ride their bike together through pleasant outdoor settings, such as riding a bicycle in a park or by the seawall. When cycling, they also see a route map, textual information and miniature photos of other cyclists. This cycling exergame runs in a web browser on a tablet mounted on the handlebar.

Figure 11 - "Exerbiking" Join-In Project, 2014, Retrieved November, 2018, from https://joininproject.wordpress.com/author/joininproject/

Pedal Tanks

Hagen and his colleagues (2016) created the game "Pedal Tanks" with a customized controller. The controller involves an off-the-shelf exercise bike, sensors detecting RPM (*i.e.* revolutions per minute), and 6 buttons attached to the handlebars of the bike (Figure 12). The RPM sensors enable the player to use the bike speed as an input to the game and the handlebars buttons enable easy input while using the bike and providing enough buttons for a varied set of actions.

For the purpose of exercising, a significant advantage of this platform is that the exercise itself is a direct input to the digital game. If the digital game succeeds to encourage the player to pedal enough, the player will be getting a good cardiovascular exercise. The act of pedalling is also easy to map to propulsion, providing an intuitive way for the player to control the game.

Figure 12 - "Pedal Tanks", Retrieved November, 2018, from https://hal.inria.fr/hal-01758455/document

Pedal Kart

The goal of Skjæran and Wang's (2018) exergame prototype entitled "Pedal Kart", which follows the Mario Kart formula, was designed to provide weekly recommended exercises in an elliptical bike, while being enjoyable enough to spur people to exercise more (Figure 13). The design principles of tying real-world movements directly to in-game movements and ensuring

varying the movement intensity, contributed to ensuring a good level of workout. In conclusion, the use of games motivated them to perform repetitive exercise movements, in comparison with the non-use.

Figure 13 - "Pedal Kart" test setup, Retrieved November, 2018, from Pedal Kart – The creation and evaluation of a cardiovascular exercise bike game (Skjæran & Wang's, 2018)

In these cycling exergames (*i.e.* Exerbiking, Pedal Tanks and Pedal Kart), exergaming is suggested to deliver short-term and mid-term enjoyment and engagement and integrate workout exercises in the individuals' daily life.

4.3. Gamification in Cycling

By searching for apps using the terms "cycling", "tourism" and "cyclo-tourism" in Google Play and Apple Store between July 2018 and May 2019, a considerable number of apps (*i.e.* more than 150 apps) that can track and register rides were identified. Most of them are very similar and were excluded to avoid repetition, whereas others are paid and do not contribute in a significant way for this study. Table 2 shows the criteria used for the app selection process.

Table 2 - App Selection Process

App	***Functionalities***	***Relevance***	***Popularity and Classification***	***Chosen***
Bikemap	Track, Register and Explore routes; Sync with other apps (limited); Share on Social Media	Cyclo-tourism	Low	No
Cyclers	Track and Register (time, distance); Share on Social Media; Community; Cycling News; Traffic News; Prizes and badges; Explore routes.	Cyclo-tourism Gamification	Median	Yes
Endomondo	Track and Register (time, distance, speed, calories, heart rhythm…); Sync with other apps; Share on Social Media; Community; Define goals; Challenges.	Cycling Gamification	Median	No
Sports Tracker	Track and Register (time, distance, speed, calories, heart rhythm…); Sync with other apps; Share on Social Media; Community; Explore routes.	Cycling	Median	No
Strava	Track and Register (time, distance, speed, calories, heart rhythm…); Sync with other apps; Share on Social Media; Community; Define goals; Challenges; Prizes and badges; Events.	Cycling Gamification	High	Yes
Zwift	Track and Register (time, distance, speed, calories, heart rhythm…); Sync with other apps; Share on Social Media; Community; Define goals; Challenges; Prizes and badges; Events.	Cyclo-tourism Gamification	High	Yes

As shown in Table 2, only three free apps were chosen, taking into consideration its popularity, classification, functionalities and relevance to the theme. These were: Cyclers[14], Strava[15] and Zwift[16]. In this dissertation, the popularity and classification criteria were based on the number of downloads and comments in Google Play and App Store; the functionalities were related to the gamification elements; and relevance was relative to its interconnection with the theme (*i.e.* Cyclo-tourism, Cycling and Gamification).

These apps can be used by the amateur or punctual cyclist as described in Chapter 3, as well by the professional one. All apps can be used via PC or MAC and Android or IOS device, although Cyclers and Strava are used outdoors and Zwift is used indoors.

Cyclers: Navigation & Community for Cyclists

The app Cyclers (Figure 14), previously known by "UrbanCyclers", combines gamification and social features in cycling. It enables the end-user to discover cycling routes, adding combinations with public transport and bicycle sharing. It notifies the user about the dangers, closures and restrictions along the route, providing short-term weather prediction and voice guidance navigation.

Cyclers can also track and save the users' rides, as well as monitor their personal stats. The app enables them to find the most popular route by crowdsourced heatmaps, rate the routes they have cycled and help cities to plan a better cycling infrastructure (see Functionalities Table 2).

In order to maintain the user motivated to continue to use the app and, more importantly, to use the bicycle, the app offers prizes and badges for the cycling achievements, the option of sharing and following friends.

[14] http://urbancyclers.com/app (Accessed: March 2019)

[15] https://www.strava.com/ (Accessed: 12 October 2018)

[16] https://www.zwift.com (Accessed: 12 October 2018)

Figure 14 - "Cyclers: Navigation & Community for Cyclists." Smarter Cycling Series: Big Data and Artificial Intelligence Are Transforming Bicycle Navigation, 16 Aug. 2017, Retrieved 29 April, 2019, from http://ecf.com/news-and-events/news/smarter-cycling-series-big-data-and-artificial-intelligence-are-transforming-1

Strava

Strava (Figure 15) is a Swedish term for "strive," which refers to the ambition to make great efforts to achieve or obtain. It enables the users to track and upload their ride and/or run activities using GPS data, either from the app on a smartphone or via a third-party GPS bike computer (*e.g.* Garmin, TomTom, Fitbit) (Strava, 2018).

The Strava's service enables millions of cyclists to connect with each other, share their ride activities and photos, being an "athlete's social media", with the facility to comment on each other's rides and give 'kudos' when they feel like it. Groups can also create clubs to organize activities or to build communities. Currently, Strava can be used to log a wide range of ride data including GPS tracked routes displayed on a map, speed, distance, power output and heart rate.

This app is considered to have all the road and rail network ever crossed by a biker or a runner, divided into two eras of resistance: before the segments and after the segments. Created by millions of Strava athletes, the segments mark sections of road or popular rails and permit to create a chart of the times recorded by every Strava athlete, who has been there before. This is an addicted tool because it incites the athlete to chase for KOMs or QOMs (*i.e.* King of the Mountain and Queen of the Mountain), creating an engagement in the physical activity (Strava, 2018).

Strava users can sign up for various motivational tasks, such as those that set a distance or a climbing goal, since it can meet their intrinsic and extrinsic motivations (*e.g.* personal progress and rewards). Progress is tracked after each race is registered and a "badge" is awarded when a challenge is completed. Given these functionalities, this app tends to change the way cyclists can communicate and compare their efforts.

Figure 15 - Strava [Nº 1 app for runners and bikers]. (n.d.). Retrieved October 12, 2018, from https://www.strava.com/

Zwift

Although Zwift seems to be an exergame because of the use of a bicycle while looking to a monitor with Virtual Reality (VR), their creators stated that it is a software, in which cities and routes are being gamified to motivate people to train indoors (Bailey, 2017).

This software consists on:

- Riding virtual roads: Cyclists can explore routes used in cycling sports and competition segments (*e.g.* Tour de France, La Vuelta and Giro d'Italia); discover the virtual world of Zwift named Watopia; climb mountains, sprint down famous stretches of road or even ride inside a bubbling volcano;

- Structured workouts: The software works with the elite World Tour coaches to design specific and personalised workouts so that cyclists can achieve what they want to become. Programs are tailored to each one's fitness level and are easy to follow. It is also possible to train alone or to join in a scheduled group workout;

- Social group rides: Zwift experience allows the end-user to ride with cyclists from over the world. The user can select numerous of events with different levels (*i.e.* from social easy rides to intense races with real prizes), in which friendly competition can maintain people motivated to finish a route and giving the best of themselves.

In order to use Zwift (Figure 16), the user needs a bike; a bicycle trainer or rollers with ANT+ or BLE power meter/speed sensor; a PC/MAC, an Android or IOS device or an Apple TV to open the software; and a bridge/receiver for the ANT+/BLE signal (Zwift, 2018). As the cyclist uses the bike pedals, the trainer permits the bike to rotate in place while the sensors send that data to the device via ANT+/BLE. Zwift then connects over the Internet to let people ride with other Zwifters around the world.

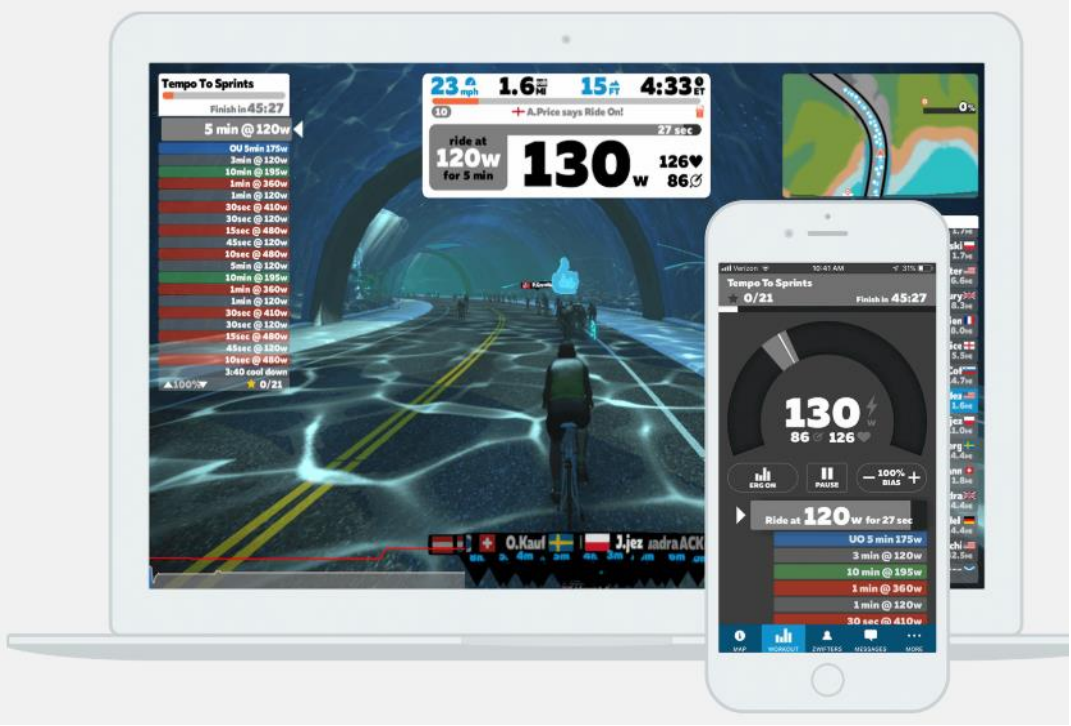

Figure 16 – Zwift [The at home training app connecting cyclists around the world] (n.d.). Retrieved October 12, 2018, from https://www.zwift.com

In response to the sub-question of this study "*What are the current market-oriented digital apps that can address cyclo-tourism?*" (mentioned in the Introduction – The Research Question), Strava is the most used app by cyclists all over the world, being very complete in terms of gamification and user's engagement. However, it does not cover the tourism aspects that are relevant to this study nor others applied to senior citizens (*e.g.* weather prediction; popular routes; nearby conveniences – hotels, hospital, bike shops; bicycle tutorials; history/culture of the location).

Zwift is another cycling app that has some tourism references (*i.e.* routes from cycling competitions), but this VR app is mainly used indoors, preventing the user to use an actual bicycle outdoors.

Cyclers is an app that is relatively new with a good aim to the cyclo-tourism segment. It has some successful features and functionalities (*e.g.* warnings) but it presents some deficiencies in terms of its application in tourism (*e.g.* lack of historical and cultural information) and sports (*e.g.* track and register speed, calories and heart rhythm).

Final Thoughts on the Literature Review

Today's reality of an aging population is a result of the world's improvement in socioeconomic development, health and living conditions and that has brought age-related challenges in product development and interface design. The number of senior citizens is estimated to rise considerably from 2002 to 2025 and that growth has led the game industry and other sectors (*e.g.* tourism) to reinvent themselves.

Digital games have been attracting senior citizens over the past few years, being their age group one of the biggest consumers (Zheng et al., 2013). That said, when designing to this target audience, there are some important guidelines to follow such as being adaptive and assisting, increasing or rehabilitating the individual's capabilities.

Nowadays, the impact of digital games is notorious. They are being used in such sectors as tourism and sports with the purpose of increasing their popularity and although they have been widely used in the sports' field, its application in the tourism sector have been overlooked.

Even if apps like Zwift can be applied to the tourism sector, they were not designed for that, relying more on the fantasy and sport with virtual characteristics. As aforementioned in previous chapters, there is a lack of work related to sports or physical exercise and tourism combined, which opens up an opportunity to approach this issue, concerning senior citizens and their adaption to their needs and preferences.

For designing a gamified app, understanding amotivation, intrinsic and extrinsic motivations is also essential in order to interlink the end-user's behaviour with persuasive design. Therefore, gamification plays an important role on this subject and that can be key components to motivate senior citizens to cyclo-tourism.

This page is left intentionally blank

5. Empirical Research

The purpose of this research is to understand the way gamification can motivate senior citizens to cyclo-tourism. In this section, an overview of the Development Research Method is presented, and the associated methods, technologies, procedures and tools used for data collection are described.

5.1. Development Research Method

As mentioned in the Introduction, the research question "*How can gamification motivate senior citizens to cyclo-tourism?"* has led to the use of Development Research Method. Such methodology framework would enable us to understand the design factors influencing the adoption of a gamified app to motivate senior cyclo-tourism and prototype a digitally-mediated solution.

The qualitative approach is contextual and occurs in a natural setting. Whether following a rigorous procedure, it can even be used to corroborate theoretical propositions from the literature review; and be applied to a number of contexts where little is known about a phenomenon, offering new perspectives of analysis (Sutton & Austin, 2015).

By using the Development Research Method, problem-solving is divided into six phases: (1) Analyse the problematic and assess to previous studies; (2) Elaborate a model during the conception process; (3) Develop strategies of achievement; (4) Evaluate the possibilities of realization; (5) Propose a prototype; and (6) Implement it (Maren, 1996).

Considering that there is a general lack of research on innovative design and development processes (Richey & Klein, 2005), identifying a conceptual framework grounded in practice environments is relevant to the foundational theory of this project.

The main reason for using this method was because 'traditional' research approaches (*e.g.* experiments, surveys, correlational analyses) with their focus on descriptive and inferential knowledge barely can meet the demands of diverse design and development problems in any research theme. Development research tends to be ambitious, innovative and complex, given the factor that it is likely to occur in the participants' natural work environments, aiming at supporting the obtained results and giving credibility to the study (Akker et al, 1999).

It is worth noting that the goal of this method is not to elaborate and implement complete interventions and have a functional product, but to originate a successive prototype that increasingly meet innovative aspirations and requirements. The process is often cyclic or spiral, by embodying the following activities: analysis, design, evaluation and revision activities, which are iterated until a satisfying balance between ideals and realization has been achieved.

Table 3 shows the scheduled activities that were carried out for the Development Research on this dissertation.

Table 3 - Scheduled activities that were carried out in the Development Research

Steps	***Dates***	***Activities***	***Method***	***Data Collection***
1 – Analysis and Evaluation of the Situation	July 2018 to April 2019	Literature review; App analysis; Plan the focus group sessions, interviews and eye-tracking.	Literature review	Systematic Literature Review
2 – Conception and Design of the Prototype	April 2019 to May 2019	<u>Conception</u>: Involve a group of senior citizens at the University of Third Age in the Co-Design Process; Interview a group of cyclists aged 55 and over from Portugal and other countries. <u>Development</u>: Design of a prototype	AXE Approach Participatory Action Research Focus Groups[17] Interviews	Participant Observation[18] Field Notes Co-Design Group Discussions Interview Guide
3 – Implementation and Evaluation	May 2019 to June 2019	Test of the prototype	AXE Approach User eXperience Eye-Tracker	Participant Observation Field Notes Eye-Tracking

As shown in Table 3, this research was divided into a 3-step process, being in accordance with the procedures undertaken in Development Research Method (Maren, 1996). These steps

[17] Focus groups can be considered either a method or a technical tool for data collection.

[18] There is a discussion whether participant observation should be considered a method or a technical tool for data collection (Jorgensen, 1989).

were: (1) Analysis and Evaluation of the Situation; (2) Conception and Design of the Prototype; and (3) Implementation and Evaluation. These activities began in July 2018 and lasted until June 2019, involving multiple sources of data (*i.e.* literature review, participant observation with field notes, interviews and eye-tracking).

For further understanding of the planned research, each step will be described in detail in terms of the activities that were carried out, the method and instruments used for data collection.

5.1.1. Description of the Research Steps

A. Step 1 – Analysis and Evaluation of the Situation

In this step, topics related with Senior Citizens, Gamification, Motivation and Cyclo-tourism were reviewed to further understand the phenomenon of the use of gamification in senior cyclo-tourism.

After the literature review conducted between July 2018 to April 2019 and app analysis (see 4. Related Work), a set of focus groups sessions, eye-tracking and interviews were planned and divided. Table 4 provides an overview of the methods that were planned.

Table 4 – Overview of the methods planned

Method	***Participants***	***Time Period***	***Session number***	***Activity***
Focus Group	Senior Citizens from the University of Third Age of Gafanha da Nazaré	May 2019	1 2 3 4	Introduction to Cyclo-tourism Take a bicycle ride Co-design App Evaluation
Eye Tracking	Senior Citizens from the University of Third Age of Esmoriz	May 29th 2019	1	App Evaluation
Interview	Cyclists aged over 55 years old from Portugal and other countries	May 2019 – June 2019	1 2	How should a cyclo-tourism app be App Evaluation

Within the scope of the SEDUCE 2.0 research project, adult learners at the University of Third Age of Gafanha da Nazaré were invited to four focus group sessions, whereas the learners of the University of Third Age of Esmoriz participated in an eye-tracking session. Additionally, an interview protocol was conducted to gather the perspective of cyclists aged 55 and over, from Portugal and other countries, on the use of game elements and techniques to motivate to cyclo-tourism.

The purpose of the sessions involving Focus Groups (Session 1, 2, 3 and 4), Eye Tracking (Session 1) and Interviews (Session 1 and 2) was to understand the needs and preferences of senior citizens relative to: (a) the use of gamified apps (activities: Introduction to Cyclo-tourism, Take a bicycle ride and How should a cyclo-tourism app be); (b) skills and competences in the use of technology (Eye-tracking activity: App Evaluation); (c) involvement of a group of senior citizens in the process of designing and developing prototypes (activities: Co-design) and usability testing for the app evaluation (all methods' activity: App Evaluation); (d) a clarification of this project framework on active aging and self-motivation concepts (activity: Introduction to Cyclo-tourism); and (e) development of a gamified app in cyclo-tourism context (activity: Take a bicycle ride and How should a cyclo-tourism app be). These planned sessions were crucial to carry out the co-design sessions described in Step 2 – Concept and Design of the Prototype.

B. Step 2 – Concept and Design of the Prototype

This step initiated with problem-solving led by the researcher and the team of participants. The researcher attempted to build alliances with the participants in order to understand and assess the senior citizens' interaction with digital devices, and this process required high levels of commitment and engagement in the search of the best solution (McIntyre, 2008). Both the researcher and participants generated game ideas and, subsequently, co-designed some of these ideas and transformed them into game concepts.

In order to understand the requirements that a gamification app should have to motivate senior citizens to cyclo-tourism, this step was performed by focus group sessions with Portuguese adult learners at the University of Third Age of Gafanha da Nazaré combined with the interviews with cyclists aged 55 and over from Portugal and other countries. According to Goodwin (2009, p.56) "combining observation with interviews will allow you to gather rich useful information […] and minimize self-reporting error" and, thus, gathering information from different sources gave further insights into prototype design.

Whereas the conception of the prototype encompasses two focus group sessions and an interview, the development of the prototype also includes one focus group session and the inputs received by the cyclists' interviewees. Tables 5 and 6 show the description of activities that were carried out in both the conception and development phase.

Table 5 – Description of the conception phase

	Session	***Description***
Focus Group	1	*Introduction to cyclo-tourism* Introduce the researcher, the research project, procedures, main goals, the topics to be drawn during the course, and chronogram; Discuss motivations to ride a bicycle, the concept of tourism and cyclo-tourism.
	2	*Bicycle ride* Use the Strava app to record and understand the pros and cons of its use.
Interview	1	*How to design a cyclo-tourism app* Acknowledge the cyclist's preferences when traveling regarding the use of an app.

Table 6 – Description of the development phase

	Session	***Description***
Focus Group	3	*Co-design* Introduce the concept of gamification (elements and examples); Show intrinsic motivation associated with gamification; Build an app by using collage techniques to meet the cyclo-tourist's needs.
Interview	2	*Inputs* Collect data from the cyclists' interview.

C. Step 3 – Implementation and Evaluation

The prototype review process was done in order to validate the created model and meet the research implementation and evaluation goals. A demo of a gamified app co-designed with the end-users was presented, played and, lastly, tested with eye-tracking. A group of cyclists' users aged 55 and over were also interviewed and tested the app, aiming at crossing different sources of data. Then, the results were interpreted.

In this step, the researcher worked as a team with the usability testers, by observing the end-users testing the prototype and discussing its design. The end-user's comments were taken into consideration for future improvements of the prototype that was build.

5.1.2. Description of the Methods Used

In the topic 'Description of the Methods Used', each method used in different research steps are explained. Whereas the first step focused on the literature review, the following methods were used in Step 2 – Conception and Design of the Prototype: (a) AXE Approach, (b) Participatory Action Research, (c) Focus Groups and (d) Interviews. In Step 3 – Implementation and Evaluation, the methods used were: (a) AXE Approach, (b) User eXperience and (c) Eye-Tracker.

- AXE Approach

Considering that AXE (Anticipated eXperience Evaluation) qualitative method relies on the user's experience and their daily life context, it was chosen for this research in order to direct the digital app towards the end-users' motivation and changes in behaviour (see 2.4. Motivation and Behavioural Design). This approach can be divided into three major steps: (1) concept briefing; (2) concept evaluation; and (3) data analysis (Gegner & Runonen, 2012).

Basically, this approach involves the establishment of design targets that enables a shared understanding of the project goals during its development and the ability to assess whether the user's perception of the concept matches the prototype development goals.

- Participatory Action Research (PAR)

According to Greenwood and Levin (2013, p.122), action research is regarded as "systematic and orientated around analysis of data whose answers require the gathering and analysis of data and the generation of interpretations directly tested in the field of action." A community-based approach towards a daily problem is followed, both involving the observant-participant researcher and the study participants.

Minkler (2000, p.191) defines Participatory Action Research as a "cyclical process of fact finding, action, reflection, leading to further inquiry and action for change", being an alternative to knowledge development and products' improvement. Another aspect of PAR is that the

participants are not only considered subjects of research, instead they are defined as active contributors, since they participate in the whole research process.

In general, PAR was applied to this research by involving the end-users in the design and evaluation process, as mentioned in 2.5. Designing for Senior Citizens. Focus groups, participant observation, field notes and interviews are some of the common effective methods used for data generation and data collection employed in PAR. These were also used in this research to gather further information and determine the components of a gamified app in cyclo-tourism, co-designed with senior citizens.

- Focus Group

A Focus Group (FG) or a discussion group is a qualitative research and data collection technique and/or method that consists of selecting a sample of individuals, who are representative of specific segments of the market or the target audience (Galego & Gomes, 2005). The participants are gathered in a common space, in sessions conducted and registered by a team of interviewers, where a structured set of questions is asked in order to gather specific information that is in accordance with the objectives set for the session (Tracy, 2013).

Focus Groups can provide valuable information in an early development stage of a product in case of getting feedback on a concept idea or a product in a timely manner. Indeed, one of the main advantages is the ability of assessing the participants' non-verbal communication and visual cues (*i.e.* facial and vocal expressions) that overpass possible limitations with their self-reported experience (Fullerton et al, 2008). When the researcher involves the participants in the co-design process of a game or an app and validate game ideas and concepts, focus groups can be an innovative source by meeting the end-user's needs and context (Fullerton et al, 2008).

- Interviews

Interviews are a method used in PAR which "enable participants to describe their situation" (Stringer, 1999, p.68), giving a broader perspective on the participants' ideas and thoughts and understanding the story associated to the participant's experiences. Both the researcher and the participant share and learn throughout the interviewing process in a reciprocal way.

A qualitative research interview seeks to cover both factual and meaningful life events of the interviewee, although in this latter, focus group are the most effective method due to the relationship build between the researcher and participants (Kvale, 2007).

The general interview guide ensures that the same topics are discussed and, therefore, the same information is collected from each interviewee. This provides not only focus, but also some freedom and adaptability in getting the information from the participant, while pursuing in-depth information around the topic (Watson, 1997).

In terms of the procedures to be undertaken, it is important to be prepared for the interview by choosing a setting with no (or minimal) distractions; explaining the purpose, format and duration of the interview; addressing terms of confidentiality; allowing the participants to feel comfortable, inquisitive and true to their answers and to ask questions; and preparing the data collection procedures and instruments (*e.g.* field notes) (Rose, 1994).

- User eXperience (UX)

UX is a term frequently used in the literature (*e.g.* Dumas & Redish, 1994; Abras et al., 2004; Seidel et al., 2005; Hassenzahl & Tracktinsky, 2006; Väänänen-Vainio-Mattila et al., 2008), but to date, a generally accepted definition is lacking. Most of the authors can agree that user experience is more than just assessing product's usability and utility, in the same way that product development is not only about implementing features and testing their usability (Seidel et al., 2005; Hassenzahl & Tracktinsky, 2006).

User experience is also considered to be the key concern in the heart of product development (Väänänen-Vainio-Mattila et al., 2008), because it brings a much more humanistic approach by relating the hedonic level of personal Human needs and values, which motivate people to use a set of products and help managers set UX targets for product development.

This means that User-centred Development (UCD) is still the key to design a good User Experience, since it is crucial to understand the users' needs and values beforehand in order to design and evaluate a prototype or validate the proposals (ISO, 1999).

According to some authors (*e.g.* Dumas & Redish, 1994; Abras et al., 2004) Usability Testing is a technique used to evaluate if a product or a service can achieve the following principles:

1. Improve the usability of a product;
2. Involve the end-users in the evaluation process;
3. Provide real tasks to the end-users;

4. Observe and register the participants' actions;

5. Evaluate the data collected and make the necessary changes.

Since it is an assessment focused on the needs of real users, it uses empirical evaluation methods in an iterative design and development process (Nielsen, 1994).

- Eye-Tracker

An eye-tracker is a stationary equipment that can measure where the end-users are looking at a certain point in time, how long they look and their eyes' path on such a broader range of devices as PC screen, laptop, tablet, smartphone or even paper. This means that it can detect the users' presence, attention and focus through the display patterns of stimulations that are exhibited on the screen.

This equipment consists of an infrared light laser, a video camera and a software. In brief, the eye-tracker projectors create a pattern of an infrared light on the cornea and pupil, enabling the cameras to detect and take high-resolution pictures of the pattern that the user's eyes do (Tobii, 2015). Then, image processing and mathematical algorithms enable the researcher to know where the user was looking by determining the point of gaze relative to the user's eyes and presented stimuli.

The main goal of using the eye-tracker was to obverse the user's gaze on a surface (Figure 17), being the eye-tracking data a prerequisite for assessing visual attention (Schiessl et al., 2003).

Figure 17 - How Eye-Tracker Works, retrieved from https://www.tobii.com/group/about/this-is-eye-tracking/ **Accessed: May 2019**

5.1.3. Techniques and Tools used for Data Collection

- Participant Observation

Participant observation that is usually used in PAR, is an innovative qualitative research method of inquiry and a rich source of data collection (Marshall & Rossman, 2006), owing to the fact that enables the researcher to engage and become a part of the observation and immersion process in the setting by hearing, seeing, and experiencing the reality of the social situation with the participants.

Participant observation requires systematic noting and recording of events, behaviours, and objects in the social setting using detailed field notes. As a result, the researcher can gather information about the events and agents of the communication process that (s)he is witnessing (Streubert & Carpenter, 1995).

- Co-Design techniques

Co-Design, originally known as co-operative design or Participatory Design (PD), results from a set of applied theories and practices that involve the end-user in activities that inform, test and drive the development of digital products and services, encouraging them to be co-designers (Muller & Druin, 2003). This technique develops a shared sense of ownership of the project with the researcher, designers and developers, among other stakeholders.

Muller and Druin (2013) draw our attention to the fact that prototyping artefacts can be considered as a co-design technique. These are aimed at the building of different products – Low or High-Fidelity prototypes – and they can be advantageous to provide a specific and descriptive view of the end users' subjective experiences and emotions. Prototyping also enables the development and incorporation of new ideas and characteristics into a product or service and its limitations and context use can be easily identified.

As part of the co-design process, the technique used was PICTIVE (Plastic Interface for Collaborative Exploration Technology through Video) (Techopedia, 2015), since it seems to be the most suitable for the engagement of senior citizens in the design process, enabling non-technological oriented people to contribute with ideas for product/service development (Schuler, 2017). PICTIVE is a paper mock-up technique that represents graphical user interfaces in paper or plastic, and that way the end-users participate in the development process,

anticipating what the prototype will look like and how it will behave, avoiding the need for the users' specialized knowledge (Schuler & Namioka, 1993).

Scenario Building was another technique that was used. Scenarios in the Human-Computer Interaction (HCI) field help the researcher to understand and suggest the applications of artefacts in Human activity (Carroll, 2000). Scenarios can be concrete and flexible, helping designers to work with the fluidity of design condition and addressing the challenge of technical design. They can promote work-oriented communication among researchers and participants, facilitating design activities and encouraging different opinions and points of view that can contribute to the design process, and meet the users' needs and concerns in different contexts (Carroll, 2000).

Combined with the techniques mentioned before, Collage was also used. Collage is a technique that has been used over 1000 years ago, although it is best-known from the technique used by famous artists such as Picasso and Braque. It is often characterized by the use of pieces of materials that are glued into a flat surface to represent a phenomenon (Butler-Kisber & Poldma, 2010) and elicit new ideas. According to Elsner and Cardinal (1994), collage can be considered as a collecting technique, in other words, different items can be gathered and grouped according to a certain pattern.

- Eye-Tracking

In a broader sense, eye-tracking is a technique, in which eye movement is recorded whilst the user is looking at an inducement/stimulus. It measures where the users are looking at, for how long, what they ignore, when they blink and how the pupil reacts to different tasks and stimulations.

Eye-tracking data is collected using an eye-tracker equipment that includes a light source (*e.g.* infrared light), a camera and possible connection to a computer. The light source is directed towards the eye, while the camera tracks the reflection of the light source along with visible ocular physiognomy, such as the pupil. This data is used to deduce the rotation of the eye and likewise the gaze direction.

This technique makes possible to understand what works and what does not work in design, giving the opportunity to test with the end-users, gather their feedback (by the eye-tracker measurements, but also their opinion of the product tested), analyse the results and implement the necessary changes to achieve a better outcome.

Eye-tracking technology has the advantage of not influencing the users, since it can record immediately the information, which is used to solve interface-related problems (Wu, 2012).

Overall, eye-tracking has potential use in UX because it is often non-invasive, which make it easier for participants to concentrate on their tasks. It is also possible to combine eye-tracking data with existing usability metrics (*i.e.* efficiency, satisfaction, accuracy), cross different sources of data and further understand the perceived problems in interface design (Bergstrom & Schall, 2014).

5.2. Research Contextualization

5.2.1. Universities of Third Age

- ***Universidade Sénior da Gafanha da Nazaré***

The aim of *Universidade Sénior da Gafanha da Nazaré*[19] is to create and foster regular social and cultural activities, educational and social, preferably to and for citizens aged 50 years old and over. The University of Third Age operates in working hours, from Monday to Friday, and adult learners can attend the courses and activities according to their interests and desires.

Educational activities are non-formal, non-certified, outside of the traditional school system and in a context of lifelong training in proactive dynamics. The program content privileges the dissemination of local and national cultural heritage, mobility, as well as it encourages cultural innovation and the use of new technologies.

The University of Third Age offers a set of social and cultural activities, taught by volunteer teachers who can also be students. Some possible Social and Cultural Activities are: Conviviality (*e.g.* parties, trips, cinema, theatre); Culture (*e.g.* museums, visits to cities, monuments, exhibitions, lectures, colloquia); and Dissemination of knowledge, knowledge and traditions. The courses offered include English, Informatics, Photography and Communication, Gardening, Dancing, Music, Sewing, and Arts.

[19]Universidade Sénior da Gafanha da Nazaré
https://www.facebook.com/universidadeseniorgafanhanazareilhavo/ (Accessed: May 2019)

- ***Universidade Sénior de Esmoriz***

The *Universidade Sénior de Esmoriz*[20] intends to promote regular social, cultural, educational and social activities aimed at people aged 50 years old and over.

The objective is to create a space for the social participation in senior citizens, fostering active aging, reducing their degree of dependence on others and enriching their personal formation and developing unexplored skills.

Some of the goals are:

(a) Improving the quality of life of senior citizens;

(b) Promoting several activities, such as social and cultural activities;

(c) Fostering senior citizens' civic participation, especially after retirement;

(d) Educating for citizenship, health, volunteering and lifelong learning;

(e) Informing senior citizens' duties and rights; and

(f) Volunteering, in and for the community.

5.2.2. Participants

The sample used in this study was purposively selected and, therefore, data cannot be extrapolated to other contexts.

As shown in Table 7, the sample consisted in 7 participants from the focus group, 8 participants from the eye-tracking and 31 participants from the interviews.

Table 7 - The number of participants of this study

Method	***Sample***
Focus Group	7
Eye-tracking	8
Interview	31

[20] Universidade Sénior de Esmoriz https://rutises.wixsite.com/esmoriz (Accessed: May 2019)

In relation to the focus group sessions, the criteria used for selecting the participants of the University of Third Age of Gafanha da Nazaré were: (a) being aged 55 years old and over; (b) know how to read and write; (c) know how to ride a bike; (d) voluntary participation; and (e) interest in learning Informatics. The sample consisted in 7 participants, 71,4% males (n=5) and 28,6% females (n=2), aged between 57 and 80 years old.

Although gender may not be adequately represented in this study and there may be some member and gender bias owing to the fact that the participants were from the same institution, the researcher ensured that all participants expressed their individual and collective opinions and experiences with, for example, the use of individual cards.

In terms of eye-tracking session, the adult learners at the University of Third Age of Esmoriz were invited to the University of Aveiro to test the online community miOne from the SEDUCE 2.0 project. The invitation was addressed to the ones who were attending the classes of Informatics, giving them the opportunity to test the online miOne community, games supported by the SEDUCE research project and the proposed cyclo-tourism app. The sample consisted in 8 participants, 50% males (n=4) and 50% females (n=4), aged between 59 and 78 years old.

In terms of the interviewees, they were invited via Facebook and Strava cycling groups. The criteria used for the participants' selection were: (a) being a cyclist; (b) being aged 55 years and over; and (c) voluntary participation. Figure 15 illustrates the percentage of interviewees' nationalities.

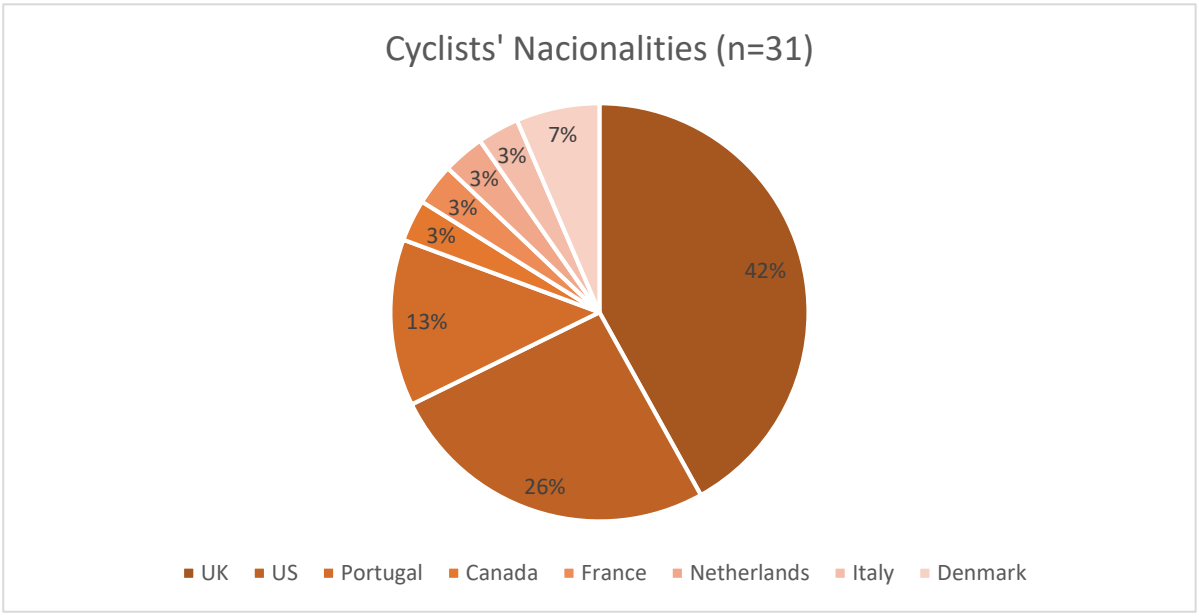

Figure 18 - Interviewees' nationalities

As shown in Figure 18, the sample consisted in 31 participants, 54,8% females (n=17) and 45,2% males (n=14). Regarding the cyclists' nationalities, 42% were from UK (n=13), 26% from US (n=8), 13% from Portugal (n=4), 7% from Denmark (n=2), 3% from Netherlands (n=1), 3% from Canada (n=1), 3% from Italy (n=1) and 3% from France (n=1).

5.2.3. The role of the researcher

In a qualitative study, the researcher has an essential role in collecting, interpreting and attributing meaning to data. It is important to have some level of experience and empathy to conduct the group discussions, collecting information and analysing the data. As overstated by Damásio (2004) in 2.4. Motivation and Behavioural Design, emotions can affect the individuals' decision-making process, and, therefore, having an impact in product design. Nonetheless, being familiar with the participants who will be involved in the research project can bring some bias to the study.

Although I have never conducted a focus group before, and only attended a few, I followed some guidelines and previous procedures on how to do it. Even though the planned sessions were tested with a research group and the first focus group session was supported by a researcher from the SEDUCE 2.0. research project in order to overpass my lack of experience, it was a completely new experience for me, with the particularity involvement of a different age group in the design process of a digitally mediated app.

Despite that, it felt natural to work with senior citizens, facilitating the process of conducting the focus group sessions, eye-tracking session and some face-to-face interviews. In the researcher's opinion, this fact contributed to the veracity of this study results, because there were no compromising results whatsoever.

5.3. Conceptualization Process

Between May and June of 2019, a set of focus group sessions (Session 1 – 3) and interviews were carried out to assess the participants' context and, subsequently, to create a gamified app that would motivate senior citizens to cyclo-tourism.

Each focus group session had an average duration of 90 minutes and took place at the University of Third Age of Gafanha da Nazaré at 3.30 pm. Senior citizens, who participated in the study were endowed with different skills and their technical insight, and involvement in prototype development was important in order to meet the requirements of a user-centred approach.

5.3.1. Focus Group Sessions

- Session 1 – Introduction

Session 1 was held at the University of Third Age of Gafanha da Nazaré on the May 7th, 2019, at 3.30 pm. The session was aided with visual presentation, cards (shown in Figure 19, 20 and 21) and post-its. Since each participant owned a bicycle and knew how to ride it, the goal of this session was to ask participants about the motivations to ride and not to ride a bike, as well discussing the benefits of riding a bike, what to bring to a bicycle ride, and how to plan and share a bicycle ride.

The participants used the cards shown in Figure 19 to write their motivations to ride on the green card and the barriers to their motivations on the red card.

Figure 19 - Cards used for the motivation's questions

Regarding the plan of the bicycle ride the participants used the card shown in Figure 20 to plan the ideal bicycle ride.

Figure 20 – Card used for the ideal bicycle ride plan

Participants also used the card shown in Figure 21 to express what, how and whom they would share their bicycle ride.

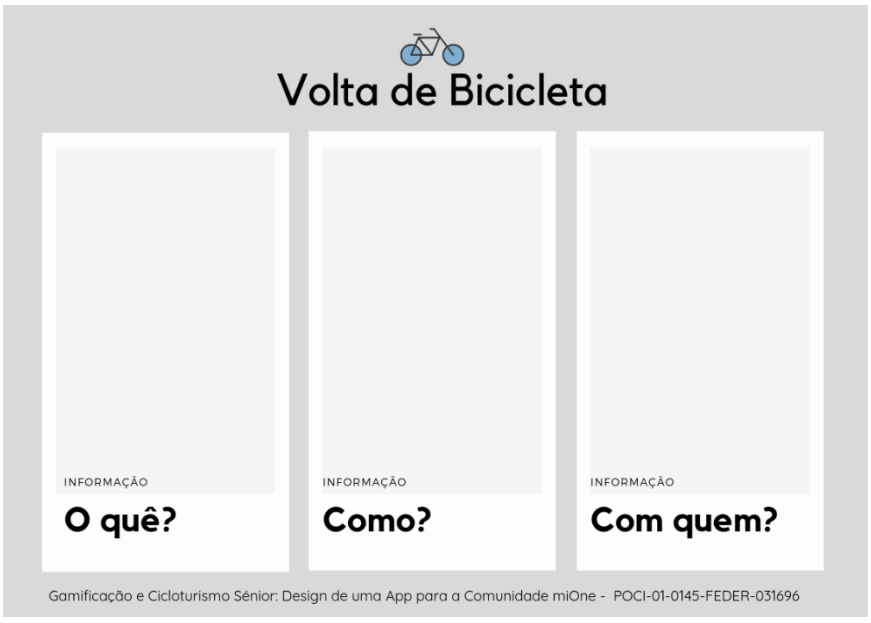

Figure 21 - Card used for the bicycle ride share

Then, a brief definition of tourism ("Set of activities involving the individual's movement from one point to another.") was provided and the participants were asked to show their vision of tourism.

Finally, the term cyclo-tourism was introduced and the participants gave their opinion on the topic after the definition was presented ("Any activity, be it cyclist or not, for those who are on vacation for more than one day, and for whom the bicycle is an essential part of the trip, even if it is not used at all the moments.") (Resende & Filho, 2011).

In the end of this focus group session, two alternatives were offered for a bicycle ride for session 2. These alternatives were due to the participants' preferences relative to the environment, distance and effort. However, they expressed some disagreement towards the proposed routes, since the starting point was not at the University of Third Age, a place they were familiar with. Hence, it was necessary to elaborate a new route that met the participants requests.

- Session 2 – Bicycle ride

This session was held on May 14th, 2019, beginning at the University of Third Age of Gafanha da Nazaré at 3.30 pm. and returning at 5.30 pm, and the participants cycled a total of 30km. The goal of this session was to assess the participants' main difficulties when interacting with the digitally-mediated platform Strava in a cycling context and identify the app limitations.

As mentioned before, a new route was elaborated to meet all the participants needs. Before starting the course, the professional road cyclist Fernando Duarte, who was recruited for assisting the cycling activity, was presented and ensured participants' safety, guidance and motivation. Helmets were given to all the participants (Figure 22).

Figure 22 - Starting point of Focus Group Session 2 - Bicycle ride

Six participants began the route from the University of Third Age, but one participant met the group halfway – POI Costa Nova. All participants had a smartphone with the Strava application installed and were asked to take pictures of what they found interesting during the bicycle ride.

- Session 3 – Co-design

Session 3 was held on May 21st, 2019 at the University of Third Age of Gafanha da Nazaré at 3.30 pm. The session was aided with a visual presentation, mock-ups cards and paper cut-outs of gamification elements (Figure 23).

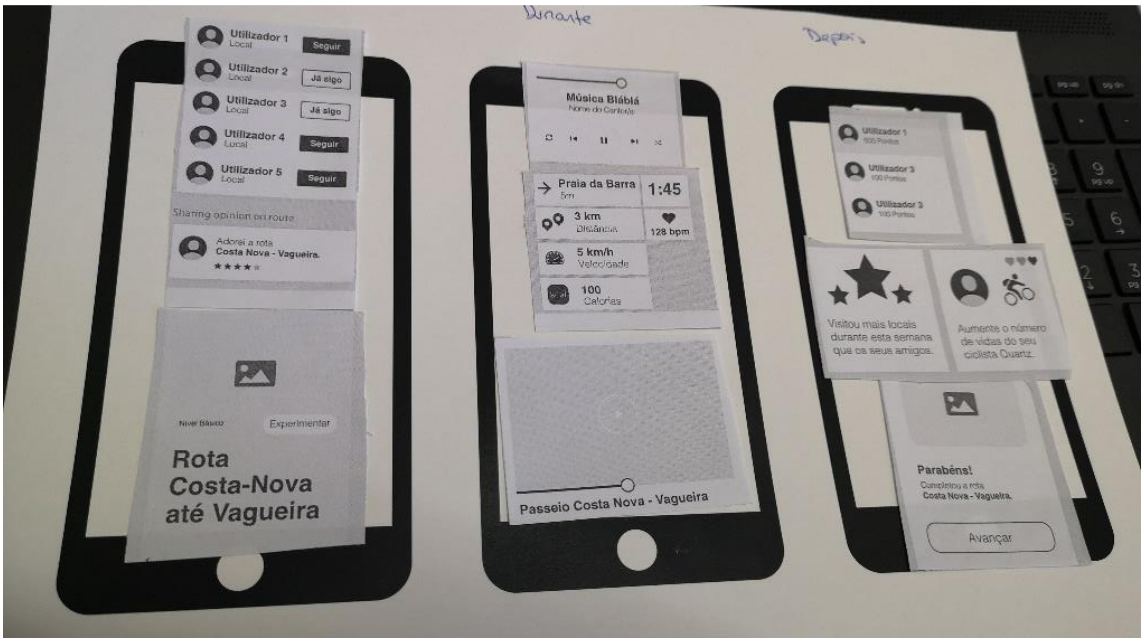

Figure 23 - Example of mock-ups cards and paper cut-outs of gamification elements from Focus Group Session 3

The gamification term was clarified and the relation between gamification and motivation was covered by providing various examples of cycling apps, as gamification elements were shown for easier understanding (Figures 24 and 25). It is worth noting that the gamification definition and motivation theories were explained in 2. Gamification and Motivation.

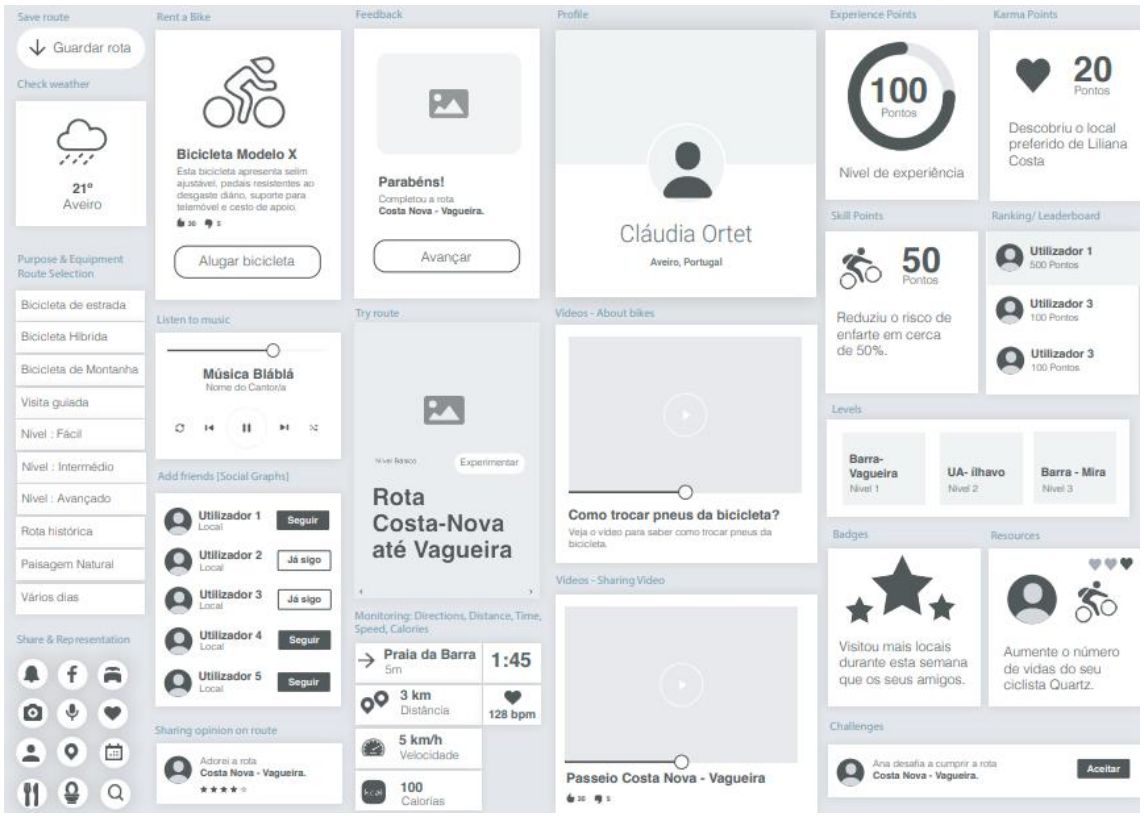

Figure 24 - Gamification Elements used in the Co-Design Focus Group Session (1)

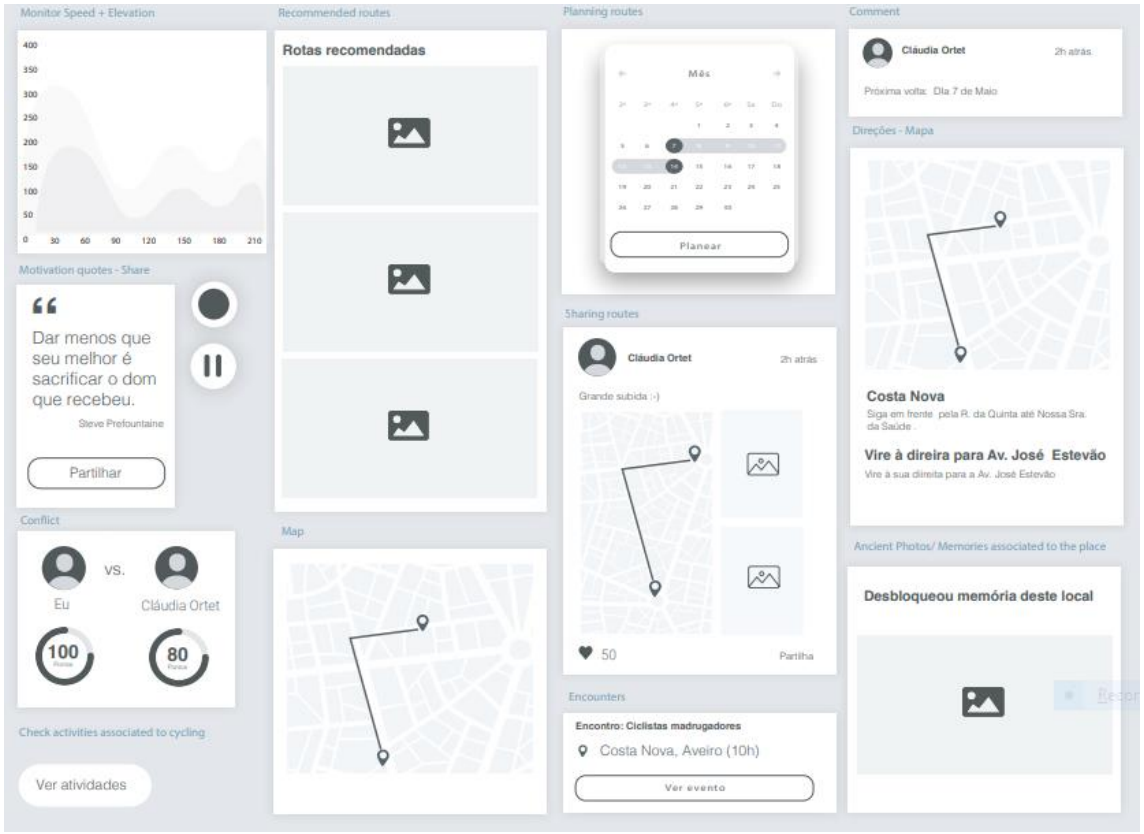

Figure 25 - Gamification Elements used in the Co-Design Focus Group Session (2)

Taking into consideration the use of Strava in the bicycle ride and all the difficulties that were found, the participants were asked to help to design an app, with gamification elements, aiming at motivating senior citizens to cyclo-tourism. A set of mockup cards and paper cuts of gamification elements were given to the end-users in order to facilitate the scenario-building and collage co-design techniques, in which each participant created two scenarios of what the perfect cyclo-tourism app would be before, during and after a ride (Figure 26).

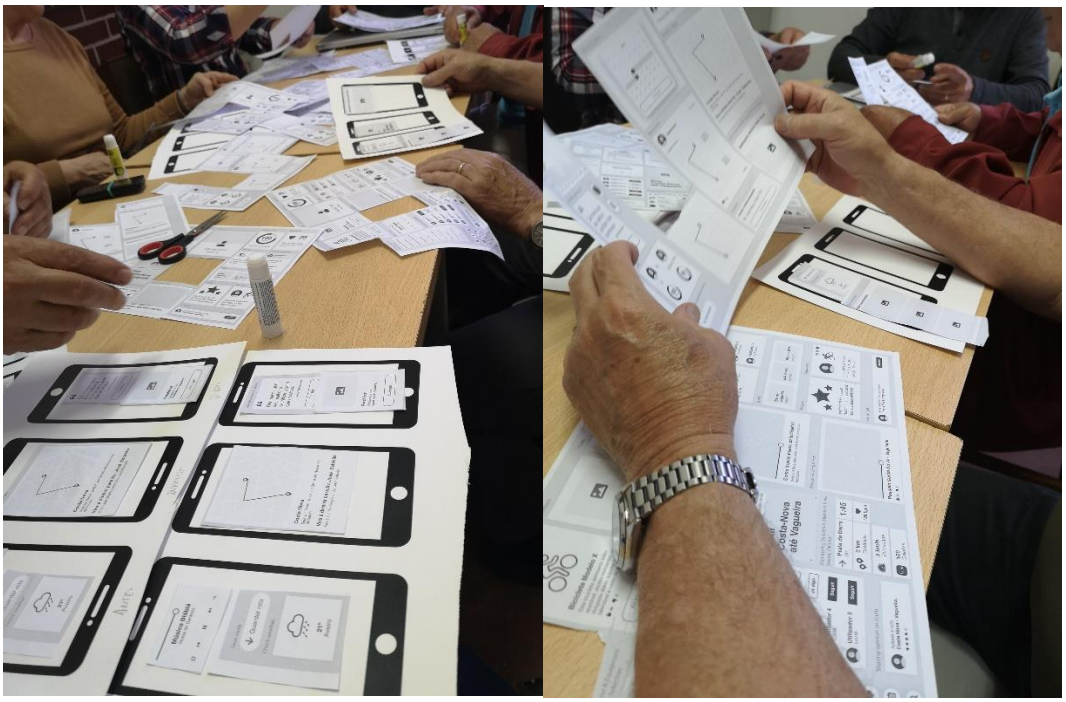

Figure 26 - Session 3 - Co-design

Based on the outputs from these sessions, the researcher developed a prototype and crossed the data obtained with the perspectives of cyclists aged 55 and over, who were interviewed.

5.3.2. Interviews

A semi-structured interview was used to gather the perspectives of bike users aged 55 and over on the use of game elements and techniques to motivate cyclo-tourism (Table 8).

In the beginning of the study, only face-to-face interviews with cyclists from Portugal were planned, but it was found to be difficult to arrange a place and hour at the both the interviewees and interviewer's convenience, causing withdrawal and non-responses (5 cyclists accepted to

do the interview but, only 2 interviewees were available). Although an online conference was also an alternative, most of the participants seemed to avoid it. Therefore, the solution found was to recruit cyclists from all over the world via an online survey, ensuring their privacy and anonymity.

After asking about their gender, age, nationality, duration and frequency of their cycling activity, a set of 6 questions with sub-questions were asked. Table 8 provides an overview of the questions used to interview cyclists aged 55 and over. The questions were then divided into data collection and data analysis questions.

Table 8 - Overview of the questions used to interview cyclists aged 55 and over

Research question	*Data collection questions*	*Data analysis questions*
How can gamification motivate senior citizens to cyclo-tourism?	1. What lead you to choose the destination for cycling?	What are the main factors that influence cyclists' destination choice?
	2. Do you use any app when you cycle? What do you do when using it?	Which are the main features that an app should have to motivate the end users to cycle?
	3. What motivates you to cycle?	What are the most cited motivations for cycling?
	4. What concerns do you have with the environment when you are on holidays or/and visit new places?	What concerns do people have with the environment and, therefore, contribute to sustainable tourism?
	5. In your perspective, what could the multimedia sector do to contribute to cyclo-tourism?	What are the key technological features and strategies that can influence changes in behaviours towards cyclo-tourism?
	6. What concerns do you have while cycling?	What are the main risks that may affect cyclists' experience?

5.3.3. The "*Jizo*" Brand

A. Naming and Logotype

An effective brand name can boost awareness and create a positive image associated to a product (Aaker, 1997). Creating a new brand name is a challenging effort, as demonstrated by the rising number of new brand names and resulting need for a corporate identity.

According to Beklemysheva (2019), the naming process is important to brainstorm ideas and associate a concept to a product or service, make the name stand out, create a meaning within the app, conduct market research and create an attractive logo.

While brainstorming ideas for the name, the purpose and the audience were in focus. The words, terms and concepts of 'cycling', 'tourism', 'cyclo-tourism', 'senior citizens', 'motivation', 'gamification' and 'assistance' were taking into deliberation, since this app intended to motivate senior citizens to cyclo-tourism by the use of gamification, including some features that other apps seem to lack.

It appeared to be impossible to find only one word that could describe the app and, also, to be persuasive. From all the names that the researcher could came up, they were too obvious, uninteresting or were already registered (*e.g.* 'bike tour', 'tour cycle', 'to cycle', 'cyclo-tour', 'tour ride' and 'to ride').

After some attempts, it was decided that the app should have a symbolic name, leading to the choice of a god's name. Searching for travel gods and what they are known for, the name 'Jizo' was the most suitable, not only for being easy to pronounce, but also for being short and meaningful. Jizo is a Japanese and Buddhist divinity that vowed to protect travellers in their physical and spiritual journey. This name was not registered in INPI[21].

Alongside the name, it was important to have an attractive logo. Ideas were generated with the aid of Looka[22], which is a platform that helps to create logos and build brands, as shown in Figure 27.

[21] Instituto Nacional da Propriedade Industrial https://servicosonline.inpi.pt/pesquisas/main/marcas.jsp?lang=EN (Accessed: May 2019)

[22] Looka https://looka.com/ (Accessed: May 2019)

Figure 27 - Logos

The logo was designed in Adobe Illustrator and the typographic representation of the word *Jizo* used a gradient of the orange colour. In addition, such elements as a cyclist with a youngster on a digital device landed on the planet Earth represents the cyclo-tourism in an intergenerational context.

In the end, the logo choice was based on the overall design of the app and included some visual elements that represent intergenerational interactions and context, in order to communicate its suitability for different age groups (Figure 28).

Figure 28 – Logo – Splash screen

B. Typography

The predominant font used in the prototype was Gibson (Figure 29), which is sans-serif, simple and easy to read because of the simpler lines. Open Sans (Figure 30), also a sans-serif font, was used to some titles in order to establish a hierarchy between elements. A sans-serif

font and a minimum text size between 12 and 14 point tend to be appropriate to display information on a computer interface used by people with low vision, such as senior citizens (Bernard et al., 2001; Fisk et al., 2009). Hence, the font size used in the prototype varies between 12 and 18 point, except for some highlights, since the fonts used have different sizes than the standard ones (*e.g.* Arial and Helvetica) and the display used is smaller than a computer interface.

Figure 29 - Gibson font

Figure 30 - Open Sans font

C. Colour

Following motivational and psychological theories, orange was the colour chosen for this prototype. According to Humphrey (2006), colours can directly affect the parts of the nervous system responsible for emotional arousal, and, therefore, it should be an important issue to psychologists and designers.

The colour orange is linked to an optimistic, uplifting and rejuvenating matter, often associated with keeping people motivated to look at the brighter side of life, being the colour of encouragement and vitality. According to Scott-Kemmis (2009), when using orange in business,

it suggests adventure, journeys, energy, flamboyance and fun, stimulating social communication and self-confidence, consequently, being appropriated to use in travel and sports business, as this prototype.

The colours used in the prototype are neutral and sober, conveying harmony, because of the target audience. Table 9 shows the colours used, the Hex code and RGB decimal.

Table 9 - Colours used in the prototype

Colour	*Hex Code*	*RGB Decimal*
	#E96556	233, 101, 86
	#78849E	120, 132, 158
	#F5F8F8	245, 248, 248
	#1B141D	27, 20, 29

D. Iconography

The icons used in the prototype seek to draw the user's attention to the main functionalities of the gamified app. Most of the icons were subtitled in order to enable a rapid association of the icons with the app functionalities (Figure 31 and 32).

Figure 31 - Menu icons

Figure 32 - Dropdown menu icons

5.4. Design Process

Based on the literature review on game design, the problems found in cycling apps, the co-design sessions and the input from cyclists, a prototype of a cyclo-tourism app was proposed.

5.4.1. Sketching the gamified app

Sketching seemed to be the best way to shorten the development process while maintaining some quality standards. In early phases of the design process, problem finding, analysis and conceptual design were some of the activities that were undertaken. Subsequently, the chances of amending errors were the highest and the use of low-expenditure sketches and material models during design were crucial (Römer et al., 2001).

Since self-made sketches can support the limited Human memory capacity and mental processing for a complete problem analysis by developing useful ideas and concepts (Rubin & Rowe, 1990), the feedback given when sketching should be as valuable as the reduction of complexity, which is a prerequisite to defining solutions (Schütze et al., 2003).

These sketches were based on the literature review, the inputs from the interviews and focus groups and what the researcher thought a cyclo-tourism app should be. In specific, the participants' feedback on the app Strava (Session 2), co-design (Session 3) and the identified features that an app should have to motivate the end-users to cycle (Interviews).

Relative to Session 2, the bicycle ride with the Strava app unraveled the following problems: (a) It did not record all the participants' routes; (b) It did not stop recording when the route was completed; (c) Although everyone cycled the same route, it did not record the same distance; (d) The Strava app was configured in miles and not in kilometres; (e) When discarding the recorded activity, that in some cases did not stop at the end of the bicycle ride, the shared group activity was not associated to each member in Strava; and (f) When inviting other participants to register the route as the same cycling activity of other group members, the application doubled the activity.

In regards to Session 3, the participants found the information about the routes, weather conditions and rental shops to be useful prior to the bicycle ride; whereas during their ride, the majority of participants printed out that they wanted to check their progress (*i.e.* distance, speed, calories, duration, bpm) and directions of the route they were taking; after the ride participants acknowledged incentives and feedback to be engaging elements to be shared on other social media, unlocking new features and interacting with other users/friends.

The game features that were identified by the cyclist interviewees and considered in the prototype were: (a) Challenges; (b) Attractions and Facilities; (c) Equipment and Safety; (d) Route Maps; (e) Performance/Statistics; and (f) Weather forecast. By taking the whole elements into account, the app mockups represented the following functionalities: (a) Save cycling activity; (b) Invite social contacts to the cycling activity; (c) Provide information about pre-determined routes; (d) Provide information about weather conditions and rental shops; (e) Monitor progress (i.e. distance, speed, calories) and reward with incentives and feedback; and (g) Provide information about bike maintenance and safety concerns.

The sketches drawn were the bases to a first version in Adobe XD, which was very simple, without significant colour, only to demonstrate the app screens and interactions, as shown in Figure 33.

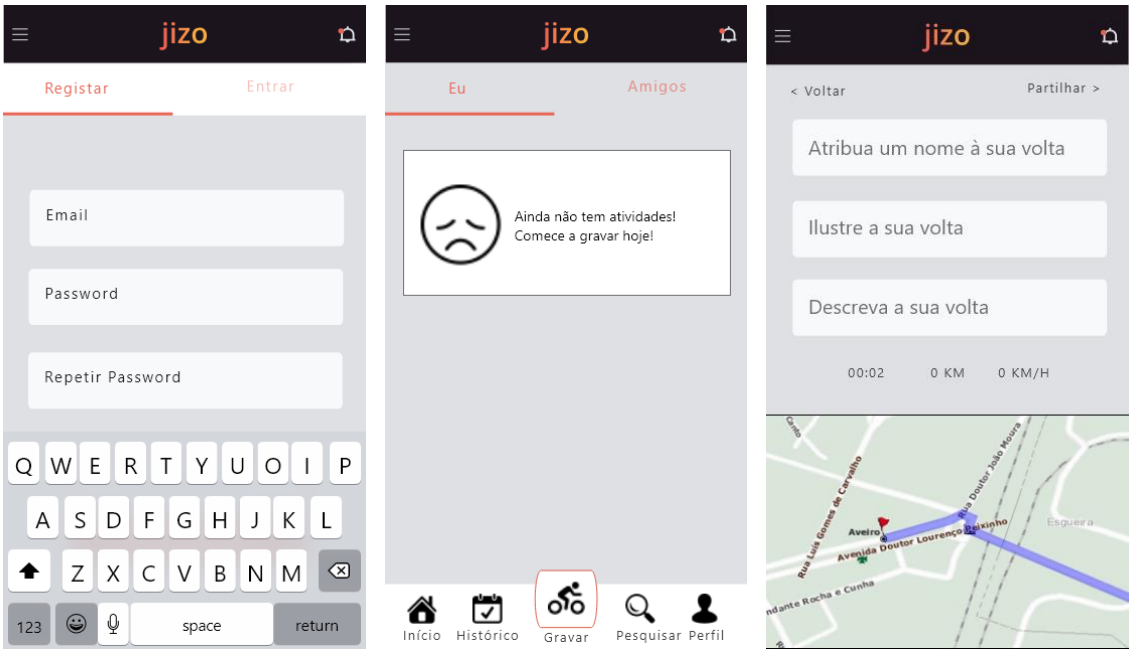

Figure 33 – Examples of the Adobe XD screens first version

This simplicity resembles to the quote "Good design does not needlessly draw attention to itself. It just works. This is the role of good design." (Sears & Jacko, 2008, page 331).

5.5. Implementation and Evaluation

After the design process and app sketching, a prototype was developed by the researcher based on the literature review and participants' inputs from focus groups and cyclists' interviewees.

A cognitive walk-through protocol was undertaken, in which the researcher instrumented a set of tasks to the participants while trying the app. The evaluation process was undertaken involving the following: (i) Focus Group session 4, (ii) Eye-tracking session and (iii) Cyclists' evaluation.

The prototype contains a sequential navigation scheme (*i.e.* onboarding and a tutorial) at the beginning of the app to help the user to understand what the app offers and what they will find when clicking the icons (Figures 34, 35 and 36).

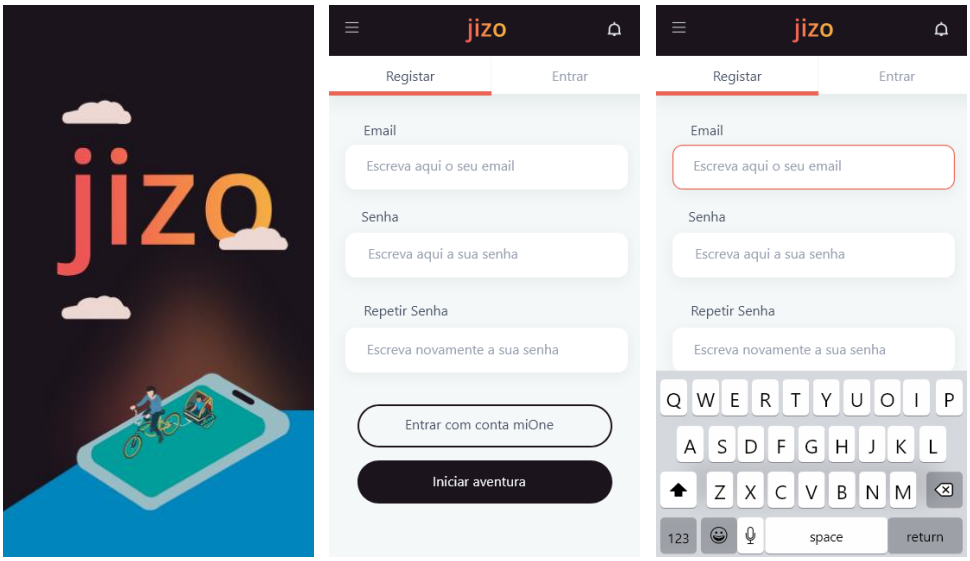

Figure 34 - Registration navigation scheme

Figure 35 - Onboarding navigation scheme

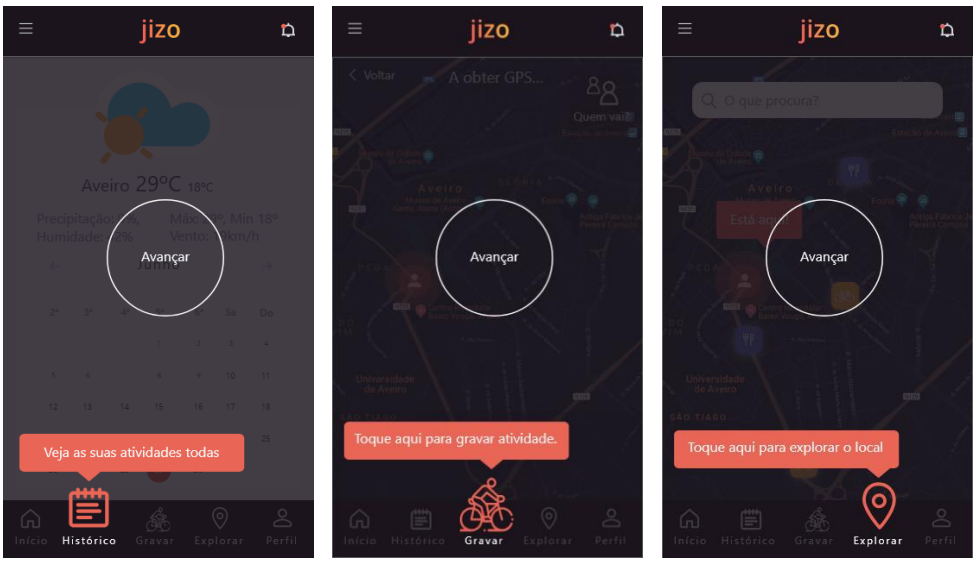

Figure 36 - Tutorial navigation scheme

As mentioned in the literature review (2.5. Designing for Senior Citizens), when designing to senior citizens it is important to include build-in game tutorials in a simple and intuitive interface, in order to be easier for them to identify and execute the activities.

Then, the participants reach the main screen and are asked to follow a friend (Figure 37), since the social interaction is a social prerequisite to induce intrinsic and extrinsic motivation (see 2.4.1. Types of Motivation).

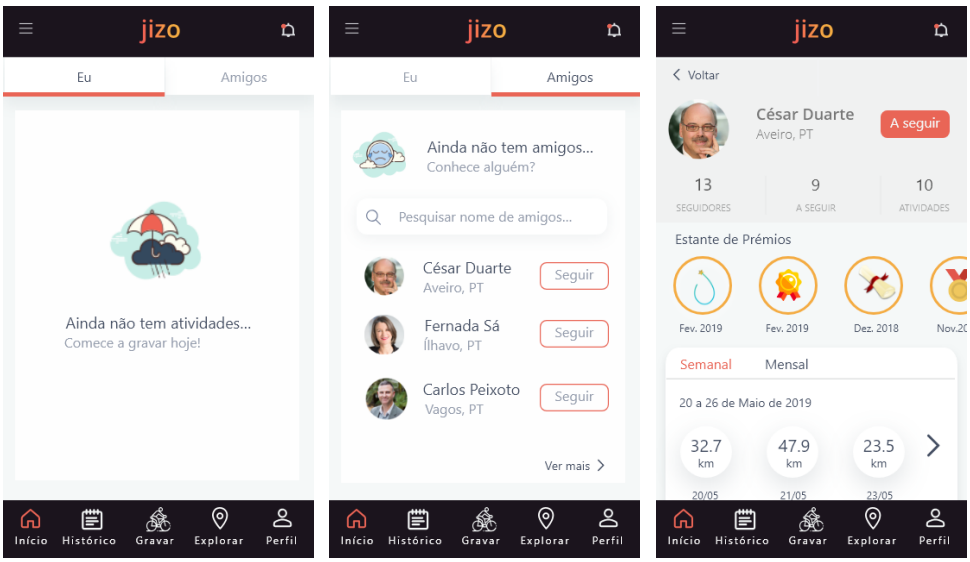

Figure 37 - Follow a friend navigation scheme

The participants were then asked to record a cycling activity, seeing the routes that the app suggests, with the option of 'free riding' and invite a friend to join the ride (Figure 38).

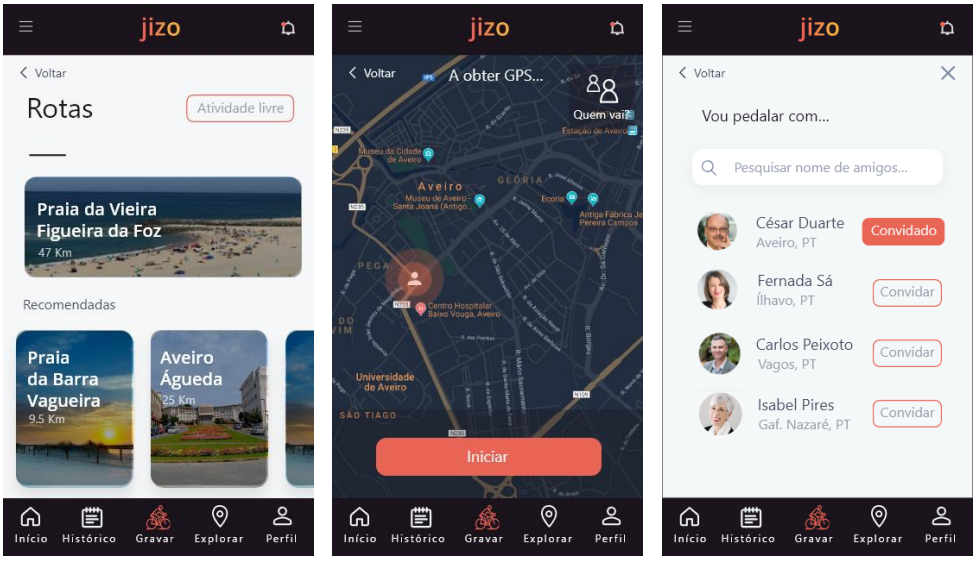

Figure 38 - See the routes and invite friend's navigation scheme

Participants referred the importance of having route maps recommendations and guidance before and during their ride, as well as having the chance of inviting friends to join their ride. Following SDT (2.4.2 Gamification and Motivation Theories), the social environmental need of relatedness is fulfilled, and users may feel autonomous in their decisions by doing a 'free activity' (*i.e.* SDT social environmental need of autonomy).

After recording the activity, they wrote a name for the ride, added photos and saved it in order to post it, as shown in Figure 39.

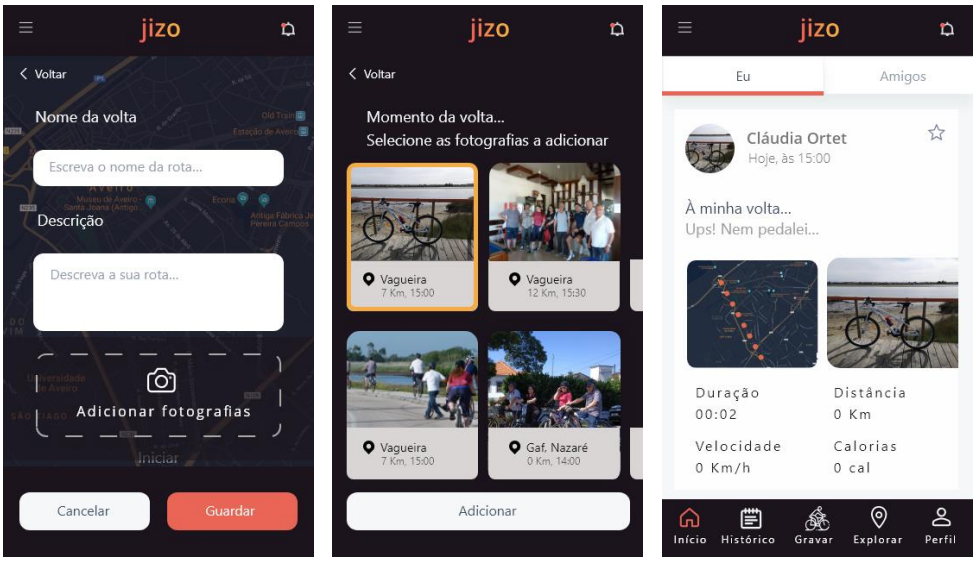

Figure 39 - Save activity navigation scheme

Then the participants were asked to explore the other menu icons (*Histórico* - Historic, *Explorar* - Explore and *Perfil* - Profile), as shown in Figure 40.

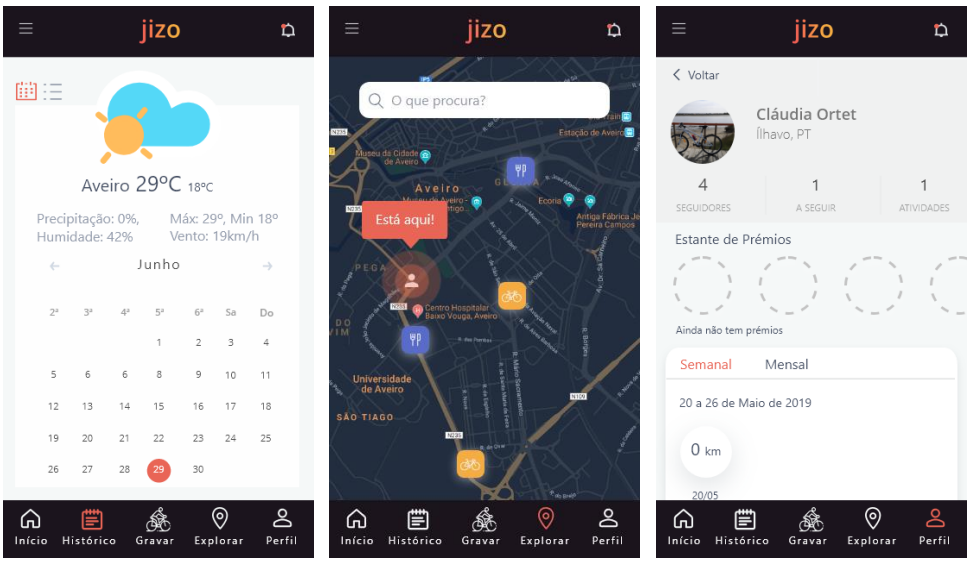

Figure 40 - Historic, Explore and Profile navigation scheme

In the end, the participants explored the notifications section (*Novidades*) and the hamburger dropdown menu (Figure 33) and all the information this feature provides (*Ciclista* – Cyclist, *Bicicleta* – Bicycle, *Desafios* – Challenges, *Notícias* – News and *Definições* – Definitions), as shown in Figure 41. Then, they logged out the application.

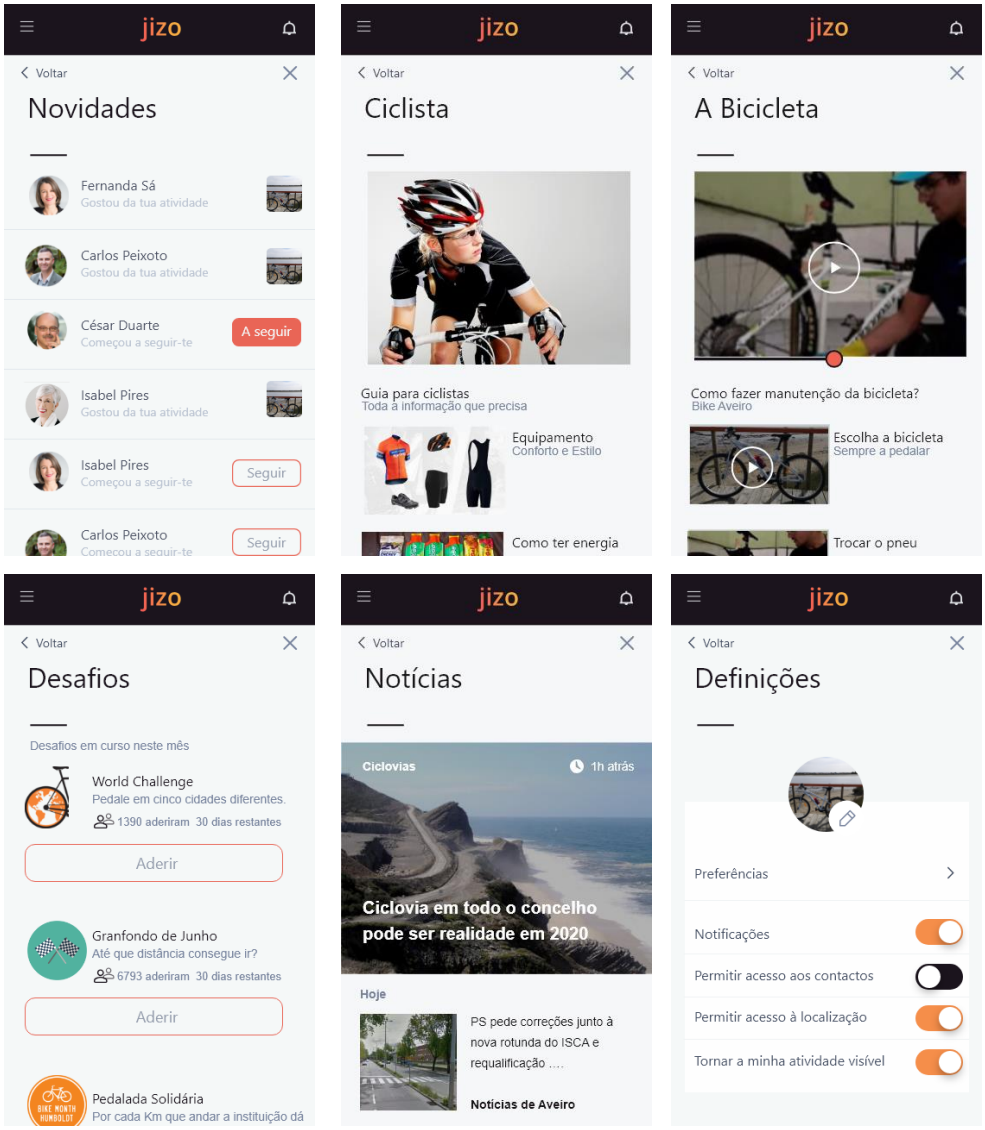

Figure 41 – Notifications, Cyclist, Bicycle, Challenges, News and Definitions navigation scheme from top left to right

Even though all the *Jizo* features are in accordance with the aforementioned gamification and motivation theories, the challenges and rewards are the most susceptible features to motivate the end-users to cyclo-tourism (see 2.4.2 Gamification and Motivation Theories). As the ARCS model (2.4.2.1 ARCS Model) puts it, the relevance of reaching a goal is determined by the users' attention, confidence and satisfaction.

It can change users' behaviour when people are motivated to do a challenge, and the demand from their abilities (*e.g.* physical effort) to perform certain activities (see 2.4.2.2. Behavioural Model). This occurs while receiving notifications and reminders of their progress and/or accomplishment.

These features are also in accordance to the eight core drives of the Octalysis (2.4.2.3 Octalysis Framework). By being able to do a challenge, the users may have the feeling that they are lucky to do it (*i.e.* epic meaning and calling), allowing them to develop skills while completing the challenge (*i.e.* developing and accomplishment). Challenges' surpass may require users' creativity (*i.e.* empowerment of creativity and feedback) in order to earn, and accumulate rewards (*e.g.* virtual goods) (*i.e.* ownership and possession). Some challenges may not only have competition and leaderboards, but may also be doable in groups to stimulate users' interaction (*i.e.* social influence and relatedness). Most of the challenges are periodical, limited and impossible to overcome in one day, which can induce users' scarcity and impatience, since they may want to complete the task all at once in order to cease their curiosity relative to the reward (*i.e.* unpredictably and curiosity) or phased, having the risk of losing progress (*i.e.* loss and avoidance).

5.5.1. Focus Group – Session 4

Session 4 was held on May 28th, 2019 at the University of Third Age of Gafanha da Nazaré at 3.30 pm. The session was aided with visual presentation and prototype testing on smartphones.

When the participants opened the app prototype in their smartphones, the app name and its meaning were clarified. To ease the navigation and show all the app features, a script was used so that the participants would access and perform the same activities throughout the session.

In the end of prototype testing, the participants filled a SWOT analysis to describe the app strengths, weaknesses, opportunities and threats.

5.5.2. Eye-tracking session

An eye-tracking session was held on May 29th, 2019 at the University of Aveiro at 2.30 pm., with participants of the University of Third Age of Esmoriz. The session involved a visual presentation, a smartphone and desktop with the prototype and eye-tracker equipment. Since

these participants did not know the researcher, a presentation introducing the researcher and the project was made before prototype testing.

The purpose for using the eye-tracking was to have an outside perspective on senior citizens' difficulties while using a digital device, considering that these participants where not cyclists and not involved in the co-design process.

Although the eye-tracker was tested and prepared beforehand in a smartphone display, there was not anticipated that the equipment would fail with the target audience due to age-related macular degeneration and aging eyes. When starting the test, the eye-tracker equipment did not recognize some of the participants' gaze, being impossible to calibrate and leading to the use of the desktop to test the app in alternative devices to a smartphone.

According to Pak and McLaughlin (2010), the aging of the musculature of the eyeball affects the pupil and that has difficulty in resizing and assuming its maximum size, which means less light entering and a consequent loss of the ability to distinguish details in low light conditions. In addition to this difficulty, as the eyepiece ages, it becomes yellowish. In the aging process, the ability to focus on details and the perception of different contrasts is lost, making reading difficult due to the aging of the ocular muscles. Another common age-related lens condition is cataracts, which are the gradual clouding of the lens, resulting in a hazy vision that is highly susceptible to glare. Figure 42 shows the Human anatomy of the eye.

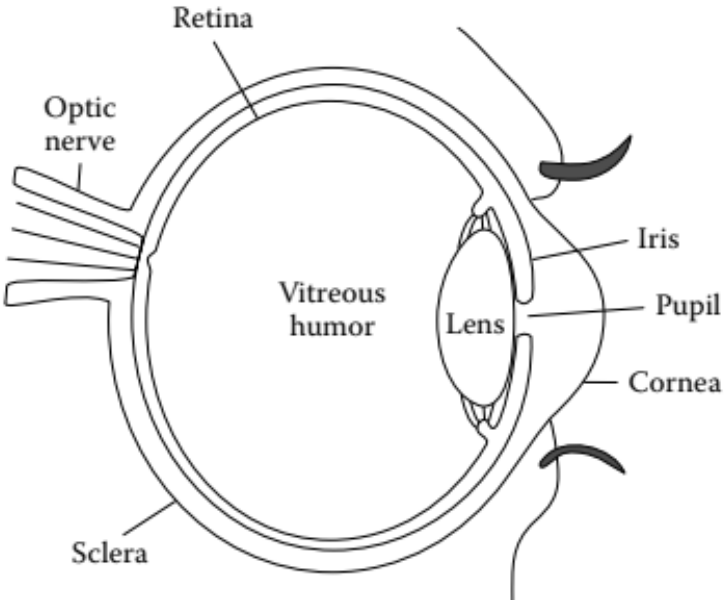

Figure 42 - Eye anatomy, retrieved from Pak, R., & McLaughlin, A. (2010). Designing displays for older adults.

Even though the difficulties encountered with the eye-tracker recognition of the same participants' eyes and calibration were due to the eye aging process of the senior citizens, it was possible to test the prototype in a desktop display (figure 43).

After the test, all the participants were surveyed about their education school, and digital literacy, cycling habits and, in the end, they commented on the digital app and SWOT analysis.

Figure 43 - Eye-tracking session in the desktop

5.5.3. Prototype Testing with Cyclists

After the interviews with the cyclists, they were invited to test the app. By providing the link to the app prototype, the task with the navigation flow scheme script and an evaluation document, the participants were able to test it and evaluate it in terms of its strengths, weaknesses, opportunities and threats.

5.6. Data Coding and Analysis

Data coding and analysis were based on the Grounded Theory (GT) that shares the characteristics of other qualitative methodologies, such as case studies, ethnography, historical narratives. The primary objective of GT is to build a theory through a systematic and rigorous data collection and analysis (Taylor et al., 2016), done through an inductive process that relies on a constant comparison between the researcher's conceptualizations from the data and the return to the data, until this process becomes saturated.

As proposed by Corbin and Strauss (1999), the qualitative analysis followed five phases:

i. 1st phase: Determine the corpus of analysis (*i.e.* text or media the researcher will analyse, interviews, field notes, all content or a selection). The technique used is re-reading the content from different data sources;

ii. 2nd phase: The units of analysis and codification (*i.e.* how the researcher will integrate the various units with meaning into categories (first descriptive and then conceptual)). The descriptive categories are used to characterize the data. This is a very time-consuming and demanding process;

iii. 3rd phase: The relationships between categories and subcategories and their elements are attributed with a certain context;

iv. 4th phase: Diagrams are designed to represent the relationship between different categories and formulate a theory or paradigmatic model;

v. 5th phase: Write the research report.

After data collection, the participants' perspectives gathered from the focus group, eye-tracking observation and interviews were divided into words, phrases or sentences using open coding. Then, their compilation in different categories was followed according to its context and number of occurrences. Data collection and analysis was performed using the NVivo 12 Plus[23] software.

- **Focus Group**

Table 10 illustrates the questioning process and NVivo tools for Focus Group data. These questions are based on the questions asked in the Focus Group sessions, although they are adapted to the data collection.

[23] https://www.qsrinternational.com/nvivo/trial (Accessed: June 2019)

Table 10 - The questioning process and NVivo tools for Focus Group

Questions	***NVivo Tool***	***Search Restriction***
Is there any relationship between the cycling motivations and the participants' gender?	Crosstab	Category: Cycling Motivation Attribute: Gender
Is there any relationship between the cycling motivations and the participants' age group?	Crosstab	Category: Cycling Motivation Attribute: Age Group
Is there any relationship between the cycling motivations and the participants' cycling frequency?	Crosstab	Category: Cycling Motivation Attribute: Cycling Frequency
Is there any relationship between the cycling barriers and the participants' gender?	Crosstab	Category: Cycling Barriers Attribute: Gender
Is there any relationship between the cycling barriers and the participants' age group?	Crosstab	Category: Cycling Barriers Attribute: Age Group
Is there any relationship between the cycling barriers and the participants' cycling frequency?	Crosstab	Category: Cycling Barriers Attribute: Cycling Frequency
What are the most cited gamified app features to be used before a cyclo-tourism experience?	Word Frequency	Category: Gamified App Features
What are the most cited gamified app features to be used during a cyclo-tourism experience?	Word Frequency	Category: Gamified App Features
What are the most cited gamified app features to be used after a cyclo-tourism experience?	Word Frequency	Category: Gamified App Features

- **Cyclists' Interviews**

Table 11 illustrates the questioning process and NVivo tools for Cyclists' interviews data.

Table 11 - The questioning process and NVivo tools for Cyclists' interviews

Questions	***NVivo Tool***	***Search Restriction***
What are the most cited motivations for cycling?	Word Frequency	Category: Cycling Motivations
Is there any relationship between the cycling motivations and the interviewees' gender?	Crosstab	Category: Cycling Motivation Attribute: Gender
Is there any relationship between the cycling motivations and the interviewees' age group?	Crosstab	Category: Cycling Motivation Attribute: Age Group
Is there any relationship between the cycling motivations and the interviewees' social context?	Crosstab	Category: Cycling Motivation Attribute: Social Context
Is there any relationship between the cycling motivations and the interviewees' cycling frequency?	Crosstab	Category: Cycling Motivation Attribute: Cycling Frequency
Is there any relationship between the gamified app feature and the interviewees' social context?	Crosstab	Category: Gamified App Features Attribute: Social Context
Is there any relationship between the gamified app feature and the interviewees' age group?	Crosstab	Category: Gamified App Features Attribute: Age Group
Which are the gamified app features that are most cited from interviewees who cycle on holidays?	Matrix Coding	Category: Gamified App Features Attribute: Cycle on Holidays (Yes/No)

- **Eye-tracking Group**

Table 12 illustrates the questioning process and NVivo tools for Eye-tracking data.

Table 12 - The questioning process and NVivo tools for Eye-tracking group

Questions	***NVivo Tool***	***Search Restriction***
Is there any relationship between the cycling motivations and the participants' gender?	Crosstab	Category: Cycling Motivation Attribute: Gender
Is there any relationship between the cycling motivations and the participants' age group?	Crosstab	Category: Cycling Motivation Attribute: Age Group

To ensure the code reliability, coding in NVivo was reviewed by a researcher of the SEDUCE 2.0 project, so that the results could be more accurate.

5.7. Ethical Procedures

This study is part of the SEDUCE 2.0 research project and it safeguards: (a) The informed consent of the participants aged 55 and over; (b) voluntary participation; (c) involvement of the research team in the process; and (d) that the risks of participating in the study do not outweigh the risks associated with the participants' daily lives.

In order to assure voluntary participation, participants were given an informed consent form, which informed the participants about the circumstances under which the study was carried out, the purpose of the research, potential risks, and benefits, the right to withdraw at any time and to refuse to answer any question. Researchers assured that all participants understand the terms of any agreement before taking part in the research project.

The risks of participating in the study do not outweigh the risks associated with the participants' daily lives and the fieldwork procedures are both closely followed and supervised by the research team.

Researchers assured the confidentiality and the privacy of the data as well as ensured that the private information was not released outside. When reporting the results, only the relevant information to the purpose of the study was written. Furthermore, all participants were randomly identified with a P and a number.

Specific procedures were undertaken for the experimental research design and interviews:

Experimental research design

Relative to the experimental research design, there were a set of ethical issues that were anticipated in this study in order to protect the participants and assure the integrity of the research:

i. Obtain the participants' consent to take part in the research project;

ii. Protect the participants' identity and treat them with respect;

iii. Explain the purpose, procedures and the duration of the group discussion and interviews;

iv. Assure the quality of the content lectured in the learning programs;

v. Ask for permission to use the NVivo software to data coding and analysis.

Interviews

Regarding the interview, the interviewees were given a consent form that informed about the way the information would be used and their rights. By signing that form, the participant agreed with the following:

i. The interview would be recorded, and a transcript produced;

ii. Direct quotations or summary interview content would be anonymized;

iii. The recording would be destroyed after 5 years;

iv. The participants would voluntarily take part in the project and had the right to stop or withdraw at any time;

v. The right to ask any questions the participants could have.

This page is left intentionally blank

6. Data Analysis, Evaluation and Discussion of Results

During prototype design and development, the adopted method "Development Research" enabled the exposition of successive results and owing to the organization of research in several phases, it is also important to organize and highlight the results obtained in each phase, and then systematize the results to draw the conclusions.

Furthermore, crossing data obtained from the results of each method used (*i.e.* focus group sessions, eye-tracking session and cyclists' interviews) had the purpose of answering the research question – *"How can gamification motivate senior citizens to cyclo-tourism?"* – and consequent sub-questions: (i) "*What are the gamification elements and techniques that can be applied to a cyclo-tourism app?";* (ii) *What are the main difficulties that senior citizens have when interacting with the games' interfaces?";* and (iii) *"What are the current market-oriented digital apps that address cyclo-tourism?"*

After gathering the participants' data from the focus group sessions and cyclists' interviews, it was possible to design the prototype – a gamified cyclo-tourism app entitled *Jizo* – and then let the same participants and other adult learners from another University of Third Age test and evaluate it. This chapter presents the results of this qualitative research from different sources: focus group, eye-tracking and interviews from a group of cyclists.

6.1. Participants' Data

Focus Group

Focus Group sessions 1, 2 and 3 had the purpose of co-designing and developing the prototype *Jizo* and assessing the senior citizens' preferences relative to the use of a gamified app.

In session 1, senior citizens' motives and barriers to ride a bicycle, objects to take for a bicycle ride, the procedures to take on cycling plan and information share were acknowledged. The researcher was also able to gather the participants' opinions on tourism and cyclo-tourism.

By searching for frequent words in the reasons for cycling and possible barriers to this activity, the following categories emerged from the participants' statements relative to cycling motives: (i) health; (ii) environment; (iii) economic; (iv) transport; (v) physical exercise; and (vi)

pleasure; in terms of barriers, these were: (i) sedentarism; (ii) weather; (iii) pavement; (iv) traffic; and (v) other preferences for alternative activities. Tables 13 and 14 show this process by compiling some of the participants' statements for each category.

Table 13 – Example of coded statements relative to motives for cycling

Categories	***Examples***
Health	"It has the ability to help both mental health and muscle health."
Transportation	"The bicycle is easy to get out of the garage."
Environmental Reasons	"I don't pollute when I am cycling."

Table 14 – Example of coded statements relative to barriers to cycling

Categories	***Examples***
Sedentarism	"I'm lazy."
Other Preferences	"I'd rather go for a walk."
Weather / Pavement	"Sometimes you do not cycle because of the weather or road conditions."
Traffic	"I am afraid to ride in the traffic."

In general, the participants acknowledge that they used the bicycle to improve their mental and physical health and avoid traffic jams (*i.e.* environmental and economic reasons). While sedentarism lifestyle negatively affects the participant's motivation to cycling, weather and pavement conditions were also referred.

When questioning the data collected from participants (Table 10), the strongest reasons that was highlighted by the participants for cycling was 'Health'. In response to the question whether there was any **relationship between the participants' motivations for cycling and gender**, 'Landscape Attractions' was the mostly cited code by male participants (n=3 refs) in comparison to female participants (n=0 refs). In the opposite, when observing the **relationship between participants' barriers to cycling and their gender**, data are not robust enough to make comparisons, even though the most cited barrier for both male and females were the 'Weather' (n= 4refs).

Regarding the **relationship between the participants' motivations for cycling and age group**, the older age group (+70 years old) pointed out that the 'Mobility' aspect as a motivation, and all age groups highlighted 'Health' being one of the strongest reasons for cycling (n=5 refs). As for the **relationship between the participants' barriers to cycling and age group**, the older age group referred 'Sedentarism' as the main barrier (n=2 refs), being the only group citing that as an impediment to cycling; and, once again, 'Weather' is the main barrier to all age groups (n= 4 refs).

By analysing the **relationship between the participants' motivations to cycling and their cycling frequency**, the participants who rides more than 1 hour considered 'Health' as their main motivation, as well as 'Cost and Benefits' of riding a bicycle. Regarding the **relationship between the participants' barriers to cycling and their cycling frequency**, the 'Weather' was once again mentioned (n=4 refs).

When participants were asked about their plan of the bicycle ride, three participants prefer to ride in the morning, while others prefer in the afternoon. The ideal duration varied from 30 minutes to 3 hours with pauses, due to the willingness to cycle, surrounding landscape; destiny and purpose (*e.g.* see the sea at the end of the day as the sun sets) and/or if it is a ride for physical maintenance. All participants share photos regarding the bicycle ride and two of them would share curiosities about what they saw (*e.g.* wildlife, flora, animals, etc.) and they usually bring water, food, helmet, tools, sunglasses and their mobile phone. The most suitable means used for sharing this piece of information would be by message and email or by exposure (*i.e.* print photos and frame photos, share on social media), and they would do it with family, friends and cyclists. Once again, the social awareness in order to perform a physical or a touristic activity is relevant (see 1.3.1. Leisure Activities for Active Aging).

Participants also stated that they used to adhere more to cyclo-tourism because they did not have a car and riding a bicycle was cheaper and more accessible than driving a car. Nowadays cycling is an expensive and elitist sport with certain investments on the equipment. When traveling, participants need such alternative modes of transport, whether they do not own a bike, being likely to need rent facilities on the local of the vacation. Therefore, as mentioned before (3.1.1 Senior Tourism), marketing tourism operators should consider senior citizens' consumption of tourism digital products, and likely *Jizo*, further information about rental shops in the cyclo-tourism destination should be provided.

In sessions 2 and 3, participants shared how a gamified app should be designed to motivate cyclo-tourism and the gamification elements to be included. During the co-design sessions, participants were taught about gamification and examples were showed to help them to understand and identify the features they liked and disliked the most in Strava and to build a digital app adapted to senior cyclo-tourism.

In general, the participants emphasised that the features that they wanted to have with such gamified app of cyclo-tourism were: access to information about the routes (*i.e.* the route and directions); weather conditions; access to bicycle mechanics and rental shops; monitor their statistics and improvements (*i.e.* distance, speed, calories, duration, bpm, elevation, climb); have incentives and competition (*e.g.* challenges, rankings and badges); feedback; share information in the app and social media; and foster interaction (*i.e.* contact other users before, during and after the ride). The following is a brief overview of one exemplar quote from a participant in the co-design session:

"There should be a way of contacting through the app other user to meet me halfway." - Focus Group Participant 05

When analysing **the most cited gamified app features to be used before a cyclo-tourism experience**, word frequency has revealed that these were: the route experience and recommendations illustrated by video and images; weather forecast; rental places and equipment information (Figure 44).

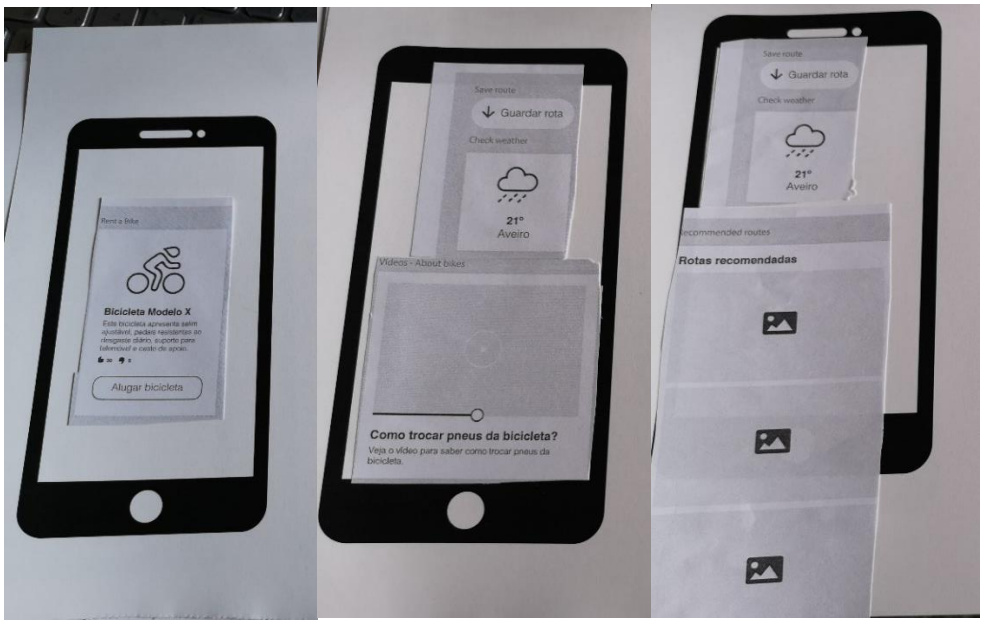

Figure 44 – Example of image of the participants' boards – Before cyclo-tourism experience

Regarding **the most cited gamified app features to be used during a cyclo-tourism experience**, these were: a video of the route with directions (*i.e.* map with directions following the cyclist path; monitoring performance by showing bpm, calories, and skills; and points or rewards) (Figure 45).

Figure 45 – Example of image of the participants' boards – During cyclo-tourism experience

Finally, as Figure 46 illustrates, **the most cited gamified app features to be used after a cyclo-tourism experience** by the participants were feedback, unlock resources, motivational quotes, badges, and leaderboards/rankings.

Figure 46 – Word Frequency of Gamified App Features After a Ride – Focus Group Participants

In a nutshell, the results of the focus group helped to identify the participants' reasons and barriers for cycling and the most relevant features for a digital app in -pre, in loco and post-cyclo-tourism experience. The gamified app *Jizo* took those elements in consideration combining them with the cyclists' interviews inputs and an eye-tracking experiment with a comparable group from another University of Third Age was conducted in order to identify the main difficulties when interacting with the digitally mediated app.

Cyclists' Interviews

Based on the question **what are the most cited motivations for cycling**? (Table 11), the Nvivo tool word frequency (Figure 47) was performed in order to understand the interviewee's motivations for cycling, which were most cited. These were fitness, freedom, friends, health (mental and physical), enjoyment, people and scenery.

Figure 47 – Word Frequency of Motivations for Cycling – Interviewees

While observing if there was any **relationship between cycling motivations and interviewees' gender,** there were some considerable differences (Table 15). Even though 'Psychological Reasons' (*e.g.* mindfulness and escape) were the most cited motivations by both

genders (n=18 refs); the codes 'Health' (*e.g.* stop smoking) (n=7 refs), 'Physical Exercise' (*e.g.* lose weight) (n=10 refs), 'Social Reasons' (*e.g.* ladies' meetings; charity) (n=6 refs) and 'Tourism' (n=5 refs) were mostly found in females' statements; whereas 'Sport Passion' was highlighted by male participants (n= 5 refs).

Table 15 – Cycling Motivations X Gender – Interviewees

Cycling Motivations	***Gender = Female (n=17)***	***Gender = Male (n=14)***
Health	7 ref	3 ref
Physical Exercise	10 ref	5 ref
Psychological Reasons	9 ref	9 ref
Social Reasons	6 ref	4 ref
Sport Passion	1 ref	5 ref
Tourism	5 ref	1 ref

In terms of the **relationship between cycling motivations and the interviewees' age group**, (Table 16) different age groups (*i.e.* 50-61 and 62-73) considered 'Health' (n=10 refs), 'Physical Exercise' (n=15 refs), 'Psychological' (n=18 refs) and 'Social Reasons' (n=10 refs) as motivations to ride a bicycle. Whereas 'Physical Exercise' is a greater motivation for the younger age group (n=10 refs), and 'Psychological Reasons' have more impact on the older age group (n=11 refs).

Table 16 – Cycling Motivations X Age Group – Interviewees

Cycling Motivations	***Age Group = 50-61 (n=14)***	***Age Group = 62-73 (n=17)***
Health	6 ref	4 ref
Physical Exercise	10 ref	5 ref
Psychological Reasons	7 ref	11 ref
Social Reasons	5 ref	5 ref

The **relationship between cycling motivations and the interviewees social context** was assessed using Nvivo tool crosstab and there were observed substantial differences between cyclists who ride alone and who ride in group or pairs, as shown in Table 17. Even though 'Physical Exercise' (n= 13 refs) and 'Psychological Reasons' (n=13 refs) are mostly cited by cyclists who ride in pair or groups, due to their number (*i.e.* n=24), cyclists who ride alone (n= 7) also considered those as their principal motivations. Meanwhile, 'Social Reasons' are motivations mostly cited by people who enjoy riding with other people (n=10 refs). It is important, however,

to mention that although some cyclists ride in pair or in groups, sometimes they can also ride alone.

Table 17 – Cycling Motivations X Social Context – Interviewees

Cycling Motivations	***Social Context = Alone (n=7)***	***Social Context = Pair/Group (n=24)***
Physical Exercise	2 ref	13 ref
Psychological Reasons	4 ref	14 ref
Social Reasons	0 ref	10 ref

In regards to the **relationship between cycling motivations and interviewees' cycling frequency**, as shown in Table 18, the motivation indicated by the interviewees who ride once a week or more than 3 times per week is 'Psychological' (n=14 refs), as for the other groups, whereas cyclists who ride between 2 and 3 times per week mentioned 'Physical Exercise' (n=9 refs) as a strong motivation for cycling.

Table 18 – Cycling Motivations X Cycling Frequency – Interviewees

Cycling Motivations	***Cycling Frequency = 1 time or less per week (n=1)***	***Cycling Frequency = between 2 – 3 times per week (n=7)***	***Cycling Frequency = more than 3 times per week (n=15)***
Health	0 ref	4 ref	3 ref
Physical Exercise	0 ref	4 ref	5 ref
Psychological Reasons	1 ref	2 ref	13 ref

Regarding the **relationship between gamified app features and interviewees' cycling social context**, as shown in Table 19, 'Performance' / 'Statistics' (n=23 refs) and 'Challenges' (n=5 refs) are referred as motivations from the participants who ride with other people in comparison to cyclists who ride solo. 'Routes Maps' (n=30 refs) and 'Weather Forecasting' (n=16 refs) were the most cited features to include in a gamified app.

Table 19 – Gamified App Features X Social Context – Interviewees

Gamified App Features	***Social Context = Alone (n=7)***	***Social Context = Pair/Group (n=24)***
Challenges	0 ref	5 ref
Attractions and Facilities	2 ref	8 ref
Equipment and Safety Concerns	1 ref	9 ref
Food and Hydration	1 ref	8 ref
Pavement Conditions	3 ref	6 ref
Routes Maps	9 ref	21 ref
Weather Forecasting	4 ref	12 ref
Performance/Statistics	4 ref	23 ref

Differences were also observed **between gamified app features and interviewees' age group**, as shown in Table 20. The groups aged between 50 and 61 years old highlighted the importance of the 'Challenges' and 'Competition' features (n=7 refs) in a digitally mediated app; whereas 'Routes Maps' (n=19 refs) tend to attract the group aged between 62 and 73 years old. This fact may be owing to the willingness of younger target groups to compete and challenge or be challenged, and the preference of older groups for familiar routes with some guidance.

Table 20 – Gamified App Features X Age Group – Interviewees

Gamified App Features	***Age Group = 50-61 (n=14)***	***Age Group = 62-73 (n=17)***
Challenges / Competition	7 ref	4 ref
Attractions and Facilities	5 ref	5 ref
Equipment and Safety Concerns / Pavement Conditions	12 ref	12 ref
Routes Maps	11 ref	19 ref
Weather Forecasting	9 ref	7 ref
Performance / Statistics	14 ref	13 ref

Related to the **gamified app features that are most cited from interviewees who cycle on holidays**, as shown in Table 21, these were: 'Routes Maps' (n=33 refs); followed by 'Equipment and Safety Concerns' / 'Pavement Conditions' (n=24 refs); 'Performance' / 'Statistics' (n=24 refs); 'Attractions and Facilities' (*i.e.* touristic sights and accommodations) (n=17 refs); and 'Weather Forecasting' (n=14 refs).

Table 21 – Gamified App Features X Cycle on Holidays – Interviewees

Gamified App Features	***Cycle on Holidays = Yes***
Weather Forecasting	14 ref
Attractions and Facilities	17 ref
Equipment and Safety Concerns / Pavement Conditions	24 ref
Routes Maps	33 ref
Performance / Statistics	24 ref

In a nutshell, the results of the cyclists' interviews helped to identify the participants' reasons for cycling and the most relevant features for a digital app in a cyclo-tourism experience.

Eye-tracking

An eye-tracking experiment was performed to record eye movement and identify the interaction difficulties with the gamified digital app *Jizo* (Table 12). The **relationship between cycling motivations and participants' gender** was assessed and the female' participants added 'Pleasure of Cycling' as an inner motivation (n=2 refs). Other motivations included: 'Health', 'Landscape Attractions', 'Mobility' and 'Psychological Reasons'. Regarding the **relationship between cycling motivations and participants' age group**, as shown in Table 22, 'Health' and 'Mobility' were the predominant motivations for the age groups between 61 to 70 years (n=3 refs), whereas others age groups did not mention it.

Table 22 – Extraction of the query Cycling Motivations X Age Group – Eye-Tracking Participants

Cycling Motivations	***Age Group = 55-61 (n=1)***	***Age Group = 61-70 (n=5)***	***Age Group = +70 (n=2)***
Health	0 ref	3 ref	0 ref
Mobility	0 ref	3 ref	0 ref

In brief, the results of the eye-tracking participants helped to identify participants' reasons for cycling. The gamified app *Jizo* was tested by this group in order to identify the main difficulties when interacting with the digitally mediated app.

6.2. Prototype – *Jizo*

In order to design the gamified digital app *Jizo*, the participants' inputs and some guidelines suggested in the literature were taken into consideration. When surveyed about the gamification elements that were important for an app to have, the participants have proposed the following elements for including in the *Jizo* app*,* based on the DMC elements (2.2. Game Design Techniques and Elements):

i. Social Relationships: The social relationships were covered by adding friends, invite them to a ride, comment and like their rides;

ii. Progression: The end-user can monitor their rides when using the *Jizo* app;

iii. Challenges: A set of goals are suggested for the end-user to achieve;

iv. Competition: Rankings/Leaderboards encourage the end-users to be better than other users;

v. Feedback: The app provides feedback by commenting the user's rides and progress;

vi. Rewards: The end-users are awarded with badges (virtual or real) for accomplishing an achievement;

vii. Win States: Users' victory or loss conditions are determined in each challenge.

After designing the app in Adobe XD, screen connections were made so that the participants could test and use all the features available at the moment (see the Navigation section in Chapter 5). A script was delivered to all participants and whereas it was read by the researcher to the participants involved in the focus group and eye-tracking, it was sent to the cyclists' interviewees.

While the focus group participants tested the app without any problems, the eye-tracking session had some mishaps. As explained before, even though several eye-trackers can handle corrective eyewear (*e.g.* glasses, contacts lenses), there were some difficulties in calibrating the

eye-tracker. In general, younger participants' gaze tend to be more detectable than senior citizens, due to age-related eye conditions.

According to Bojko (2013), one of the recognized problems associated with older participants involves droopy eye lids, which cause the pupil to be partially covered by the eye lashes, resulting in data offsets or loss. Therefore, very few participants tested the app on the mobile stand for the eye tracker (Figure 48), but instead on the desktop, since the eye-tracker could track the participants' eye gaze on that angle, since it was aligned with the device, as shown in Figure 49.

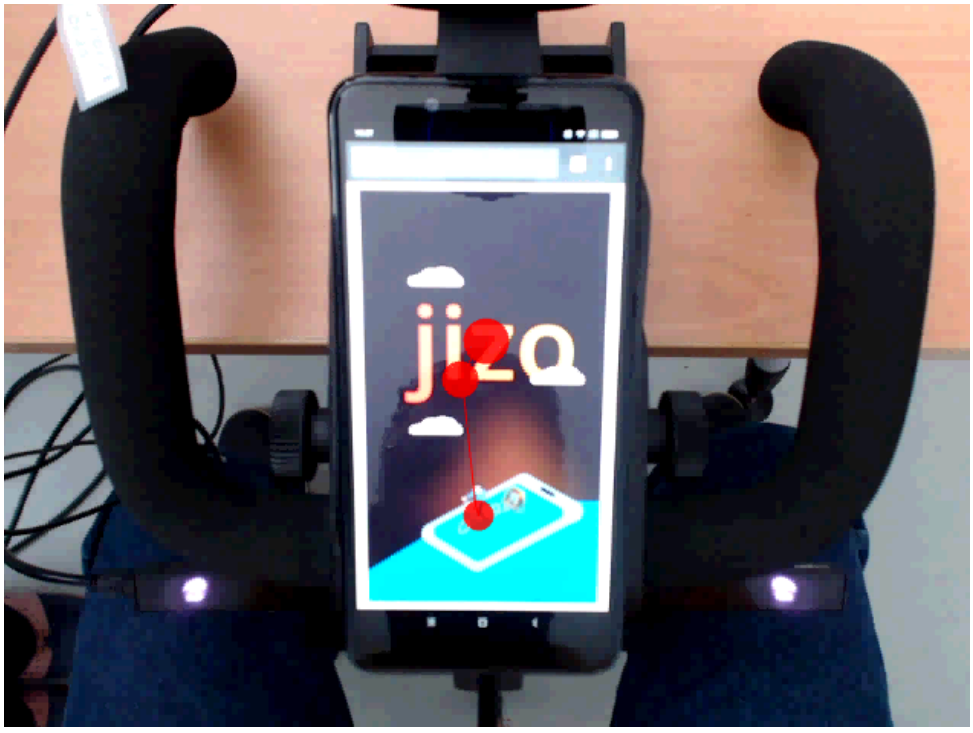

Figure 48 – Participant eye-tracking on the smartphone

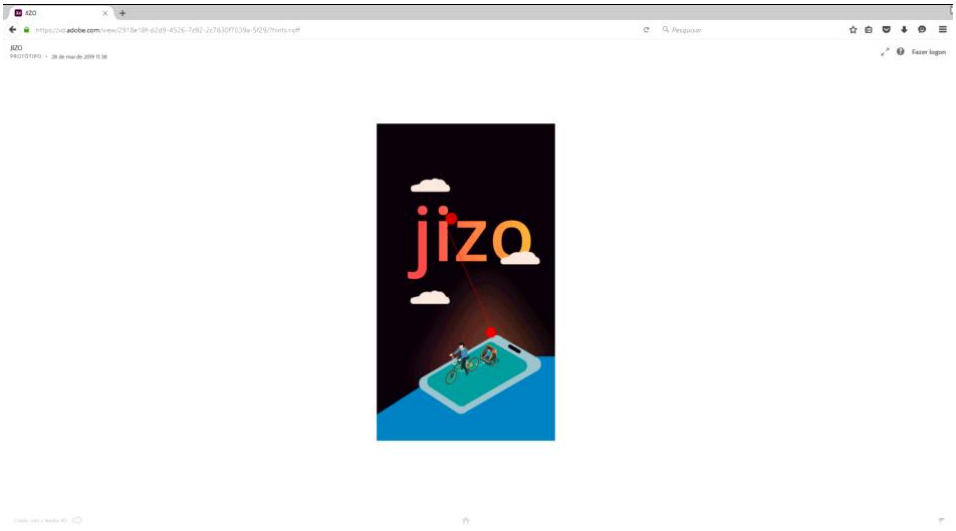

Figure 49 – Participant eye-tracking on the desktop

To evaluate the participants' eye-tracking performance, the fixation points (*i.e.* the period of time where the eye is kept aligned with the target for a certain duration) and saccades (*i.e.* type of eye movement used to move the fovea rapidly from one point of interest to another) were taken into consideration.

According to Salvucci and Goldberg (2000), fixation can be divided into spatial criteria, including velocity, dispersion and area-based; and temporal criteria, including duration sensitive and locally adaptive. A fixation is composed of slower and minute movements (*e.g.* micro saccades, tremor and drift) that help the eye align with the target and avoid perceptual fading.

For the analysis, the researcher analysed the videos from the eye-tracking session and was able to recognize the main difficulties found in the app. These were: Dealing with digital devices; Understand the task; Find the task's correspondent icons to move to the next task; and Understand the icons' meaning.

While the participants who used the mobile stand had more difficulties due to dealing with a smaller display, the participants who used the desktop display had more saccades and difficulties in fixating the right icons. This act may be owing to the aging process of the eye. Figure 50 illustrates some moments of good fixation when performing a task, whereas Figure 51 shows fixation and saccades when reading the content and, lastly, Figure 52 illustrates pure disorientation without fixation, only saccades.

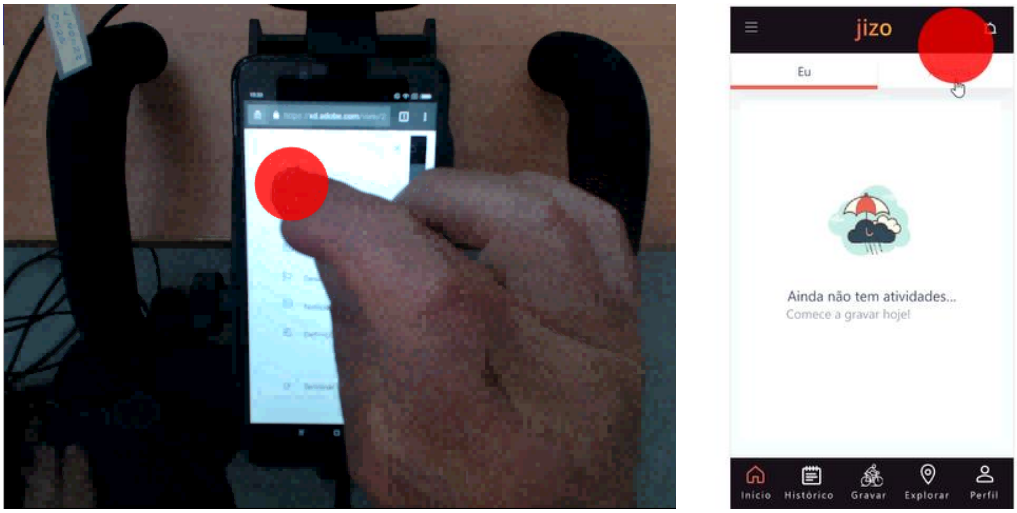

Figure 50 – Good Fixation Point in Smartphone and Desktop – Eye-Tracking

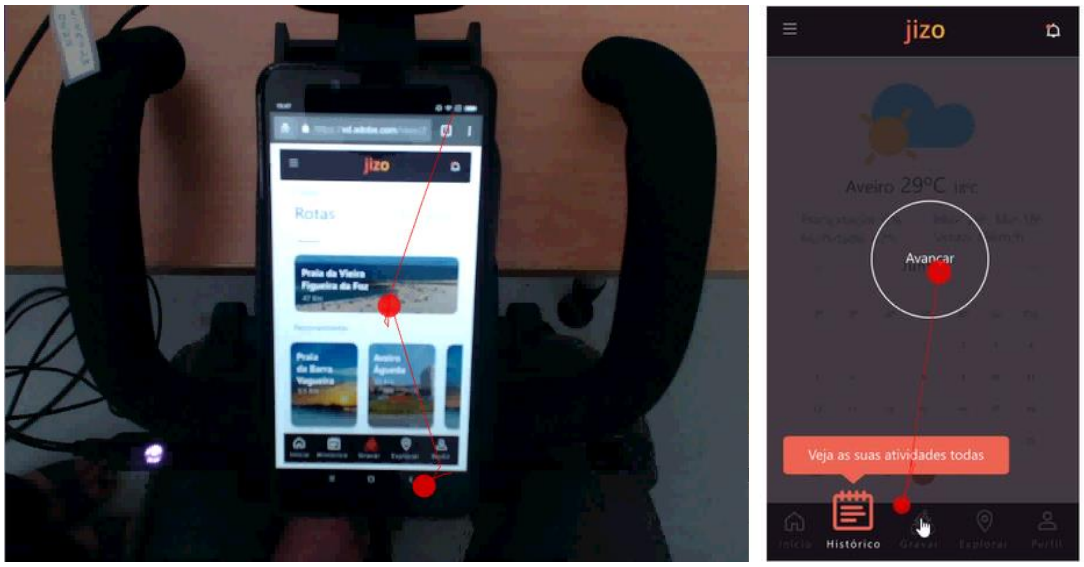

Figure 51 – Eye Fixation and Saccades in Smartphone and Desktop – Eye-Tracking

Figure 52 – Saccade due to Disorientation in Desktop – Eye-Tracking

In order to acknowledge *Jizo* potentialities, all the participants (*i.e.* Focus Group participants, Eye-Tracking participants and Interviewed Cyclists) identified the strengths, weaknesses, opportunities and threats of the digitally mediated app (SWOT analysis), as shown in Table 23. In this table, there is an overall description by all the participants.

Table 23 – SWOT Analysis – *Jizo*

Strengths	***Weaknesses***	***Opportunities***	***Threats***
Invite a friend	Few Stats	Use worldwide	Other apps
See local routes	Icons identification	Be an official cyclo-tourism' events app	Not be well promoted and divulgated
Information	Lettering size	Use for other activities	
Layout and Design		Connect people from around the world	
Tutorial		To motivate to cyclo-tourism	
Take photos			
Explore City			
Originality			
Accessibility			

To sum up, it is possible to identify numerous strengths relative to the *Jizo* app (*i.e.* introductory tutorial, the functionality to invite friends for a ride and tracking their location; see local and touristic routes; ability to explore the city POI; take photos without leaving the app; all cycling information were available; originality; accessibility; layout and design) and opportunities (*i.e.* ability to be used worldwide; to be used for other activities; to be an official cyclo-tourism app; to connect people from all over the world; and motivate cyclo-tourism), as well as corrections to be made to face the weaknesses (*i.e.* icons identification; lettering size; and few monitoring statistics available) and threats (*i.e.* other apps; and to not be well promoted and divulgated). Some participants share their opinion not only about *Jizo*, but also about their experience in the involvement of this project:

"I enjoyed participating in this project, it was interesting, I felt like my opinion mattered and it was really useful." - Focus Group Participant 03

"I hope that this app goes to the market, I bet it can beat other cycling apps because is so much more complete." - Cyclist 19

Therefore, *Jizo* is a gamified digital app designed by and for senior citizens to adhere to cyclo-tourism, being, most likely, pioneer in that mission. This app does not only have gamified functionalities that can induce inner user's motivations to cycling, but also important aspects for tourism such as weather prediction, popular routes, nearby conveniences, points of interest and information relative to the sport culture. These features combined are what makes this app unique, in comparison with other apps (see 4. Related Work).

6.3. Discussion

The evaluation of the app prototyped by cyclists and senior citizens from different Universities of Third Age shown that the implemented prototype can motivate senior citizens to cyclo-tourism by (a) providing information about the pre-determined cycling routes, weather conditions, rental shops, bicycle maintenance and safety concerns; and (b) offering the possibility to invite friends for a bicycle ride, challenges, among other features. However, it presents usability aspects that need to be improved in order to meet the app requirements. Based on the results obtained from the focus group, eye-tracking and interviews, a second iteration would be needed to redesign some of the functionalities and return to the step Conception and Design of the Prototype.

In accordance to the initial expected results formulated in the Analysis Model, this research found that senior citizens involved in cyclo-tourism tend to use the smartphone and access to cycling apps. The participants also stated that gamification elements are important and can motivate them to the activity.

Findings suggest that the main gamification elements that motivates senior citizens towards cyclo-tourism are the competition and challenges, with constant feedback about their progression, in order to receive rewards and share with social contacts.

It is important to acknowledge that senior citizens have some difficulties dealing with digital devices and technologies, as well as there is a tendency to not ride a bicycle more often due to several constrains (*e.g.* physical limitations, pavement conditions, traffic, weather). Therefore, findings have important implications for developing a gamified app targeted to senior citizens aged 55 and over and understand the intrinsic and extrinsic motivations associated to cyclo-tourism.

Conclusion

This section presents the main conclusions from the overall research. It addresses the research question regarding the selected features of a gamified app and explains how the features managed to motivate senior citizens to cyclo-tourism. A set of sub-questions identified in the Introduction are answered and the research conclusions regarding the initial expected outcomes and goals are revealed. Finally, the research contribution in the field, its limitations and future work are also presented.

Addressing the Research Problem

During the first step – **Analysis and Evaluation of the Situation -**, bibliographical references on the different scientific areas were analysed, which allowed to take note of the studies and investigations carried out up to the present date. The literature was reviewed and covered in the first four chapters of the dissertation. In these chapters, keyword concepts were the Senior Citizens and an overview of aging and its effects, as well as Active Aging. The concept of Gamification with its theories inherent to the concept of Motivation were also described. The theme of Cyclo-tourism was also approached with emphasis on senior tourism.

In the first step, the first sub-question **"What are the current market-oriented digital apps that address cyclo-tourism?"** was answered by the literature, and it was possible to find that, even though several apps can be used for that purpose, Strava, Zwift and Cyclers are the most used.

In the literature review, the use of gamification and how its elements and techniques could motivate senior citizens to cyclo-tourism were studied. However, this literature was insufficient to understand senior citizens' preferences to play and which elements should be included in the prototype. Hence, adult learners at the University of Third Age needed to be involved in order to co-design a gamified cyclo-tourism app. So, the second step – **Conception and Design of the Prototype** – enabled the researcher to gather information from cyclists' interviews and focus group participants to answer the second sub-question **"What are the gamification elements and techniques that can be applied to a cyclo-tourism app?"** In response to this sub-question, the co-designed gamification app *Jizo* embodied the following game elements: competition,

challenges, social interaction, rewarding, win states, feedback and progression. A set of guidelines to create a gamified app adapted to this target audience were also proposed.

In the last step – **Implementation and Evaluation** – the participants were able to test the gamified app *Jizo*. Whereas the cyclists' interviewees were familiar with cycling apps and the focus group participants helped in the conception and development process, the eye-tracking participants did not have previous contact with the prototype. This fact enabled the researcher to answer the third sub-question **"What are the main difficulties that senior citizens have when interacting with the games' interfaces?"**, and the findings corroborate with the literature review, which the main difficulties were understanding the task, problems with lettering and icons size and the overall limited dexterity when dealing with digital devices.

In response to the research question **"How can gamification motivate senior citizens to cyclo-tourism"**, the following gamification elements were highlighted: social relationships, progression, challenges, competition, feedback and rewards. These can motivate senior citizens by adding friends; commenting and liking their activity; inviting them to their rides; monitoring their progression; achieving a set of goals; trying to be better than other users through the use of rankings and leaderboards; receiving feedback on their progress and activities; and being awarded with virtual or real badges.

When applying these gamified elements to senior cyclo-tourism, a set of endorsements were suggested to each experience stage:

- Pre-experience: route recommendations, weather forecast, information about cycling equipment and bicycle rental shops;
- *In loco*: route directions, performance monitoring, points achievements and rewards; and
- Post-experience: motivational quotes and feedback, unlock resources, badges earnings, rankings and leaderboards.

Overall, the goals established in the beginning of the research were accomplished and the conclusions from this study are in accordance with the research question, in which gamification can motivate senior citizens to cyclo-tourism by including elements that the target audience considered as triggers to the activity.

Limitations and Future Work

A number of limitations of this research study should be considered. Firstly, as mentioned before, 'Gamification and Senior Cyclo-tourism' is an unexplored topic. However, this research is innovative and not a replication or adaptation from other similar studies.

Secondly, a convenience sample was used, so attempts to generalize beyond these respondents are not warranted and results should be interpreted with caution. Considering that this study has an international dimension, getting a random sample of each country would be interesting but unfeasible in a short period. For that, the research would need to be extended in time.

Thirdly, there may be some members' bias in the results obtained, owing to the fact that the focus group participants were from the same institution. However, the researcher ensured that all participants expressed their individual and collective opinions and experiences with, for example, the use of cards.

Regarding future work, further research needs to be carried out in motivation and the psychology field in order to deepen the understanding in gamification and motivation, while observing if the communication skills can affect anxiety and have an impact on behaviour change and frequency of cyclo-tourism.

Recruiting a sample of senior citizens who are not motivated to cycling would be also an interesting challenge that could bring more viability and added value to the project, in comparison to the sample of this dissertation. Furthermore, this research does not sufficiently cover cyclo-tourism and the use of the bicycle in the Portuguese context in comparison with other countries. Given the international dimension of this research, the author did not get into detail in terms of the national initiatives that have been undertaken and compared with other countries. Further work would be needed in order to make such a comparison.

A game narrative could be also a more interactive and efficient way to motivate senior citizens and different generations. During prototype design and development, mechanisms of Artificial Intelligence (AI) and Augmented Reality could also be considered in order to associate virtual avatars to a set of points of interest and local history or tourism. Another interesting feature for the ones who cannot go outside to ride a bicycle, due to physical limitations, fears (*e.g*. fear of riding in traffic areas) and/or environmental causes (*i.e.* bad weather), would be the possibility of exergaming *Jizo*.

This page is left intentionally blank

References

Aaker, D. A. (1997). *Managing brand equity: Capitalizing on the value of a brand name*. New York, NY: Free Press.

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. In W. Bainbridge (Ed.), *Encyclopedia of Human-Computer Interaction*. Sage Publications.

Adventure Cycling Association (2015). Discover What Awaits. (n.d.). Retrieved from https://www.adventurecycling.org/

Aison, C., Davis, G., Milner, J., & Targum, E. (2002). Appeal and interest of video game use among the elderly. Harvard Graduate School of Education, (May 2002), i-28. DOI= http://www.jrmilner.com

Akker, J. V., Branch, R., Gustafson, K. Nieveen, N. & Plomp, T. (1999). *Design approaches and tools in education and training*. Dordrecht: Springer Science Business Media

Alff, D. (2017, February 15). The History Of Bicycle Touring - How It Got Started. Retrieved from https://bicycletouringpro.com/history-of-bicycle-touring/

Aln, E., Dominguez, T., & Los, N. (2012). New Opportunities for the Tourism Market: Senior Tourism and Accessible Tourism. *Visions for Global Tourism Industry - Creating and Sustaining Competitive Strategies*. doi:10.5772/38092

American College of Sports Medicine (2009). Chodzko-Zajko, W.J., Proctor, D.N., Fiatarone Singh, M.A., Minson, C.T., Nigg, C.R., Salem, G.J., Skinner, J.S. American College of Sports Medicine position stand. *Exercise and physical activity for older adults*. Med Sci Sports Exerc. 2009; 41(7):1510–30.

Anderson-Hanley, C., Arciero, P. J., Westen, S. C., Nimon, J., & Zimmerman, E. (2012). Neuropsychological Benefits of Stationary Bike Exercise and a Cybercycle Exergame for Older Adults with Diabetes: An Exploratory Analysis. *Journal of Diabetes Science and Technology,6*(4), 849-857. doi:10.1177/193229681200600416

Antonucci, T. (2001). Psychology of Social Support. *International Encyclopedia of the Social & Behavioral Sciences,*14465-14469. doi:10.1016/b0-08-043076-7/01699-5

Bailey, M. (2017, November 03). Zwift: The story behind the indoor cycling phenomenon. Retrieved from https://www.telegraph.co.uk/health-fitness/body/zwift-story-behindindoor-cycling-phenomenon/

Ballagas, R., Kuntze, A., & Walz, S. P. (2008). Gaming Tourism: Lessons from Evaluating REXplorer, a Pervasive Game for Tourists. *Lecture Notes in Computer Science Pervasive Computing,*244-261. doi:10.1007/978-3-540-79576-6_15

Barata, G., Gama, S., Jorge, J., & Goncalves, D. (2013). Engaging Engineering Students with Gamification. *2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)*. doi:10.1109/vs-games.2013.6624228

Barnett, L. M., Bangay, S., Mckenzie, S., & Ridgers, N. D. (2013). Active Gaming as a Mechanism to Promote Physical Activity and Fundamental Movement Skill in Children. *Frontiers in Public Health,1*. doi:10.3389/fpubh.2013.00074

Beklemysheva, A. (2019, January 21). How to Choose the Perfect Name for Your App. Retrieved May, from https://steelkiwi.com/blog/how-to-choose-perfect-name-your-application/

Berardi, N., Sale, A., & Maffei, L. (2017). Optimizing cognition in older adults: Lifestyle factors, neuroplasticity, and cognitive reserve. *Oxford Medicine Online*. doi:10.1093/med/9780198701590.003.0166

Bergstrom, J. R., & Schall, A. J. (2014). *Eye tracking in user experience design*. Amsterdam: Elsevier.

Bernard, M., Liao, C. H., & Mills, M. (2001). The effects of font type and size on the legibility and reading time of online text by older adults. *CHI 01 Extended Abstracts on Human Factors in Computer Systems - CHI 01*. doi:10.1145/634164.634173

Bojko, A. (2013). *Eye tracking the user experience: A practical guide to research*. Brooklyn, NY: Rosenfeld Media.

Bond, J., Peace, S., Dittmann-Kohli, F., & Westerhof, G. J. (2008). *Ageing in society: European Perspectives on Gerontology*(3rd ed.). London: Sage.

Butler-Kisber, L., & Poldma, T. (2010). The power of visual approaches in qualitative inquiry: The use of collage making and concept mapping in experiential research. Journal of Research

Practice, 6(2), Article M18. Retrieved from http://jrp.icaap.org/index.php/jrp/article/view/197/196

Cafazzo, J. A., Casselman, M., Hamming, N., Katzman, D. K., & Palmert, M. R. (2012). Design of an mHealth App for the Self-management of Adolescent Type 1 Diabetes: A Pilot Study. *Journal of Medical Internet Research,14*(3). doi:10.2196/jmir.2058

Camerer, C. F. (2014). *Behavioral game theory: Experiments in strategic interaction*. New York: New Age International.

Carroll, J. M. (2000). Five reasons for scenario-based design. *Interacting with Computers,13*(1), 43-60. doi:10.1016/s0953-5438(00)00023-0

Chou, Y. (2017). *Actionable gamification: Beyond points, badges, and leaderboards*. Milipitas, CA: Octalysis Media.

Clark, J., Lamphear, A., & Riddick, C. (1987). The effects of video game playing on the response selection processing of elderly adults. *Journal of Gerontology, 42*, 82-85.

Corbin, J., & Strauss, A. (1990). Grounded Theory Research: Procedures, Canons and Evaluative Criteria. *Zeitschrift Für Soziologie,19*(6). doi:10.1515/zfsoz-1990-0602

Corre, E. L. (2018, October 23). Physical Fitness: Its History, Evolution, and Future. Retrieved November, 2018, from https://www.artofmanliness.com/articles/the-history-of-physical-fitness/

Costa, L. & Grist, H. (2017). Ageing in a network society: An Introduction. Networking Knowledge: Journal Of The MeCCSA Postgraduate Network, 10(1), 1-4. Retrieved from http://ojs.meccsa.org.uk/index.php/netknow/article/view/499

Costa, L., & Veloso, A. (2016). Being (Grand) Players: Review of Digital Games and their Potential to Enhance Intergenerational Interactions. Journal of Intergenerational Relationships, 14(1). https://doi.org/10.1080/15350770.2016.1138273

Cox, P. (2012). Strategies Promoting Cycle Tourism in Belgium: Practices and Implications. *Tourism Planning & Development,9*(1), 25-39. doi:10.1080/21568316.2012.658167

Damásio, A. R. (2004). *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*. London: Vintage.

Deci, E. L. (1975). Inequity and Intrinsic Motivation. *Intrinsic Motivation,*187-206. doi:10.1007/978-1-4613-4446-9_7

Deci, E. L., & Ryan, R. M. (1985). Conceptualizations of Intrinsic Motivation and Self-Determination. *Intrinsic Motivation and Self-Determination in Human Behavior,*11-40. doi:10.1007/978-1-4899-2271-7_2

Deci, E. L., & Vansteenkiste, M. (2004). Self-determination theory and basic need satisfaction: *Understanding human development in positive psychology. Ricerche di Psicologia, 27(1), 23e40.*

Demirbilek, O. (1999). Involving the elderly in the design process: a participatory design model for usability, safety and attractiveness. BILKENT UNIVERSITY.

Demirbilek, O., & Demirkan, H. (2004). Universal product design involving elderly users: A participatory design model. *Applied Ergonomics,35*(4), 361-370. doi:10.1016/j.apergo.2004.03.003

Derboven, J., Van Gils, M., & De Grooff, D. (2012). Designing for collaboration: a study in intergenerational social game design. Universal Access in the Information Society, 11(1), 57–65. doi: https://doi.org/10.1007/s10209-011-0233-0

De Schutter, B. (2001) Never to old to play: The appeal of digital games to an older audience. *Games and culture, 6*(2), 155-170. doi: 10.1177/1555412010364978

Deterding, S. (2011). Situated motivational affordances of game elements: A conceptual model. *CHI 2011 Hans Bredow Institute for Media Research*. Retrieved from http://gamification-research.org/wp-content/uploads/2011/04/09-Deterding.pdf

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness. *Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek 11*. doi:10.1145/2181037.2181040

Deterding, S., Sicart, M., Nacke, L., Ohara, K., & Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. *Proceedings of the 2011 Annual Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA 11*. doi:10.1145/1979742.1979575

Dewsbury, G., Sommerville, I., Bagnall, P., Rouncefield, M., & Onditi, V. (2006). Software Co-design with Older People. *Designing Accessible Technology,*199-208. doi:10.1007/1-84628-365-5_20

Domínguez, A., Saenz-De-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education,63*, 380-392. doi:10.1016/j.compedu.2012.12.020

Drew, B., & Waters, J. (1986). Video Games: Utilization of a novel strategy to improve perceptual motor skills and cognitive functioning in the non-institutionalized elderly. *Cognitive Rehabilitation, 4*(2), 26-31.

Dumas, J. S., & Redish, J. C. (1994). *A Practical Guide to Usability Testing* (p. 404). Portland: Intellect Ltd.

ECF (2014). European Cyclists' Federation. Retrieved from http://www.ecf.com/

Economias. (2019, April 29). Idade da reforma em Portugal em 2019. Retrieved from https://www.economias.pt/idade-da-reforma-em-portugal/

Elsner, J., & Cardinal, R. (1994). *The Cultures of Collecting*(Ser. 709). London: Reaktion Books.

ETC (1994) Annual European Travel Commission Report. Europe`s senior travel market. *Journal of Travel Research,32*(3), 74-74. doi:10.1177/004728759403200338

Figueroba, A. (2017). Los 4 cambios psicológicos en la vejez (memoria, atención, inteligencia, creatividad). Retrieved from https://psicologiaymente.net/inteligencia/cambios-psicologicos-en-vejez#!

Filipe, C.S.M. (2009). Andanças do Turismo Criativo*. Dissertação de Mestrado em Gestão e Desenvolvimento em Turismo, Departamento de Economia, Gestão e Engenharia Industrial.* Aveiro: Universidade de Aveiro.

Fisk, A. D., Rogers, W. A., Charness, N., Czaja, S. J., & Sharit, J. (2009). *Designing for Older Adults - Principles and Creative Humane Factors Approaches* (Second ed.). London: Taylor & Francis. doi:10.4324/9780203485729

Fogg, B. (2009). A Behavior Model for Persuasive Design. *Proceedings of the 4th International Conference on Persuasive Technology - Persuasive 09*. doi:10.1145/1541948.1541999

Forsell, Y., Jorm, A. F., & Winblad, B. (1997). Suicidal thoughts and associated factors in an elderly population. *Acta Psychiatrica Scandinavica,95*(2), 108-111. doi:10.1111/j.1600-0447.1997.tb00382.x

Fullerton, T., Swain, C., & Hoffman, S. (2008). *Game design workshop: A playcentric approach to creating innovative games*(2nd ed.). Amsterdam: Morgan Kaufmann.

Galego, C., & Gomes, A. A. (2005). Emancipação, ruptura e inovação: O "focus group" como instrumento de investigação. *Revista Lusófona De Educação, 5(5),* 173-184.

Gamberini, L., Martino, F., Seraglia, B., Spagnolli, A., Fabregat, M., Ibanez, F., Alcaniz, M., & Andres, J. M. (2009). Eldergames project: An innovative mixed reality table-top solution to preserve cognitive functions in elderly people. In 2nd Conference on Human System Interactions, 2009. HSI'09, 164–169. doi: 10.1109/HSI.2009.5090973

Gantar, A., Kočiš, D., & Pehnec, M. (2012). *How to develop cycle tourism?* Project-Bicy.Eu. Maribor

Gazzola, P., Pavione, E., Grechi, D., & Ossola, P. (2018). Cycle Tourism as a Driver for the Sustainable Development of Little-Known or Remote Territories: The Experience of the Apennine Regions of Northern Italy. *Sustainability,10*(6), 1863. doi:10.3390/su10061863

Gegner, L. & Runonen, M. (2012). For What it is Worth: Anticipated eXperience Evaluation. 8th International Conference on Design and Emotion (London, UK, 2012). https://reseda.taik.fi/Taik/jsp/taik/Publication_Types.jsp?id=23583813

Gerling, K. M., Schulte, F. P., Smeddinck, J., & Masuch, M. (2012). Game Design for Older Adults: Effects of Age-Related Changes on Structural Elements of Digital Games. *Lecture Notes in Computer Science Entertainment Computing - ICEC 2012,*235-242. doi:10.1007/978-3-642-33542-6_20

Goldstein, J., Cajko, L., Oosterbroek, M., Michielsen, M., van Houten, O., and Salverda, F. (1997). Video games and the elderly. *Social Behavior and Personality, 25*(4), 345-352. doi:10.2224/sbp.1997.25.4.345

Goodwin, K. (2009). *Designing for the digital age: How to create human-centered products and services*. Indianapolis, IN: Wiley Pub.

Greenwood, D. J., & Levin, M. (2013). *Introduction to action research social research for social change*. Johanneshov: MTM.

Groot, G. C., & Fagerström, L. (2010). Older adults motivating factors and barriers to exercise to prevent falls. *Scandinavian Journal of Occupational Therapy,18*(2), 153-160. doi:10.3109/11038128.2010.487113

Guerrinha, S. (2019). *Metaphysics Terminology*.

Hagen, K., Chorianopoulos, K., Wang, A. I., Jaccheri, L., & Weie, S. (2016). Gameplay as Exercise. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA 16,*1872-1878. doi:10.1145/2851581.2892515

Harada, C. N., Natelson Love, M. C., & Triebel, K. L. (2013). *Normal Cognitive Aging. Clinics in Geriatric Medicine, 29(4), 737–752.* doi:10.1016/j.cger.2013.07.002

Hassenzahl, M. & Wessler, R. (2000). Capturing design space from a user perspective: the Repertory Grid Technique revisited*. International Journal of Human-Computer Interaction*, 12, 441-459.

Horton, D. (2006). Environmentalism and the bicycle. *Environmental Politics,15*(1), 41-58. doi:10.1080/09644010500418712

Humphrey, N. (2006). *Seeing Red: A Study in Consciousness*. Cambridge, MA: The Belknap Press of Harvard University Press. doi:10.4159/9780674038905

Hunicke, R., Leblanc, M., & Zubec, R. (2004). MDA: A Formal Approach to Game Design and Game Research. *Proceedings of the Association for the Advancement of Artificial Intelligence Workshop on Challenges in Game AI*, San Jose, California. Retrieved from http://www.cs.northwestern.edu/~hunicke/MDA.pdf

Huotari, K., & Hamari, J. (2012). Defining gamification. *Proceeding of the 16th International Academic MindTrek Conference on - MindTrek 12*. doi:10.1145/2393132.2393137

Instituto Nacional de Estatística. Statistics Portugal. (2016). Report of the INE of Estatísticas Demográficas 2016 [Demographic Statistics 2016] 76th edition of the thematic yearbook on Demography, published by Statistics Portugal (INE, IP).

ISO 13407:1999, Human-Centred Design Processes for Interactive Systems. International Standardization Organization (ISO), Switzerland. doi:103403/01779042

Join-In Project (2014). Introduction to exergames designed in Join-In – Exerbiking, AntiqueHunt, Walking game. (2014, February 14). Retrieved from https://joininproject.wordpress.com/tag/games-for-the-elderly/

Jeffrey, F. (2011). World Travel Market 2011 Industry Report (2011, November 12). Retrieved from https://london.wtm.com/

Jorgensen, D. L. (1989). *Participant observation: A methodology for human studies*.

Kalache, A. & Keller, I. (2000). "The greying world: a challenge for the 21st century". Science Progress 83 (1), 33-54.

Kalmijn, M. (2003). Shared friendship networks and the life course: An analysis of survey data on married and cohabiting couples. Social Networks, 25(3), 231-249.

Kaplan, D. B., & Berkman, B. J. (2016, August). Introduction to Social Issues in the Elderly - Geriatrics. Retrieved October, 2018, from https://www.msdmanuals.com/professional/geriatrics/social-issues-in-the-elderly/introduction-to-social-issues-in-the-elderly

Kapp, K. M. (2012). *The Gamification of Learning and Instruction: Game-based methods and strategies for training and education*. San Francisco: Pfeiffer.

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development,10*(3), 2-10. doi:10.1007/bf02905780

Kvale, S. (2007). Doing Interviews. doi:10.4135/9781849208963

La Chaire de Tourism de l'UQÀM (1999). Le cyclotourisme au Québec à l'heure de la Route verte - Portrait global de la situation et perspectives. (1999, June). Retrieved from https://chairedetourisme.uqam.ca/

Lieberman, D.A. (2009). Designing serious games for learning and health in informal and formal settings. In: Ritterfeld U, Cody M, Vorderer P, eds. Serious games: mechanisms and effects. New York: Routledge; 2009, 117–30.

Llano, M., Manz, M. & Oliveira, S. (2003). Guia Prático da Actividade Física na 3ª Idade, Évora.

Loos, E. (2017). Exergaming: Meaningful Play for Older Adults? *Human Aspects of IT for the Aged Population. Applications, Services and Contexts Lecture Notes in Computer Science,*254-265. doi:10.1007/978-3-319-58536-9_21

Loverseed, H. (2000). "The mature market in North America", *Travel & Tourism Analyst, Nº 3*, pp. 47 - 65.

Maillot, P., Perrot, A., & Hartley, A. (2012). Effects of interactive physical-activity video-game training on physical and cognitive function in older adults. *Psychology and Aging, 1\qz27*(3), 589-600. doi:10.1037/a0026268

Mandolesi, L., Polverino, A., Montuori, S., Foti, F., Ferraioli, G., Sorrentino, P., & Sorrentino, G. (2018). Effects of Physical Exercise on Cognitive Functioning and Wellbeing: Biological and Psychological Benefits. *Frontiers in Psychology,9*. doi:10.3389/fpsyg.2018.00509

Maren, J. V. (1996) *Méthodes de recherche pour l'education.* Belgique: De Boeck Université. Retrieved from: http://classiques.ugac.ca/contemporains/Van_der_Maren_jeanmarie/methodes_recherche_education/methodes.html

Marshall, C. & Rossman, G. (2006). Designing qualitative research, (4th Ed.). Thousand Oaks: Sage

Marsili, M., & Capacci, G. (2014). *Proceedings of the Sixth Eurostat/Unece Work Session on Demographic Projections*. Roma: Istituto Nazionale di Statistica.Ageing Alone? The Future of the Portuguese Population in Discussion

Maslow, A. H. (1954). *Motivation and personality*. New York: Harper & Row.

Mazo, G. Z., Mota, J., Gonçalves, L. H., Matos, M. G., & Carvalho, J. (2008). Actividade física e qualidade de vida de mulheres idosas da cidade de Florianópolis, Brasil. *Revista Portuguesa De Ciências Do Desporto,2008*(3), 414-423. doi:10.5628/rpcd.08.03.414

McIntyre, A. (2008). Participatory action research. Thousand Oaks, CA: SAGE Publishing

McGonigal, J. (2012). *Reality is broken: Why games make us better and how they can change the world*. London: Vintage.

McKibbin, D. (2015). Cycling for leisure, recreation and tourism. Research and Information Service Briefing Paper. Retrieved from:

http://www.niassembly.gov.uk/globalassets/documents/raise/publications/2015/regdev/2415.pdf

Meirelles, L. D., Simon, D., & Regner, A. (2017). Neurotrauma: The Crosstalk between Neurotrophins and Inflammation in the Acutely Injured Brain. *International Journal of Molecular Sciences,18*(5), 1082. doi:10.3390/ijms18051082

Merz CN & Forrester JS (1997). "The secondary prevention of coronary heart disease". American Journal of Medicine, 102: 573-80.

Microsoft (2014). Kinect Effect Reaches Into Hospitals, Senior Centers. (2014, October 17). Retrieved from https://news.microsoft.com/2011/12/19/kinect-effect-reaches-into-hospitals-senior-centers/

Minkler, M. (2000). Using participatory action research to build healthy communities. *Public Health Reports,115*(2), 191-198. doi:10.1093/phr/115.2.191

Mortal Journey. (2011). Penny Farthing Bicycle (1860's). March 6, 2011. Retrieved from https://www.mortaljourney.com/2011/03/all-trends/penny-farthing-bicycle-and-the-history-of-the-bicycle

Muller, M., & Druin, A. (2003). Participatory Design: The Third Space in HCI. *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications,*1051-1068.

Negruşa, A., Toader, V., Sofică, A., Tutunea, M., & Rus, R. (2015). Exploring Gamification Techniques and Applications for Sustainable Tourism. *Sustainability,7*(8), 11160-11189. doi:10.3390/su70811160

Nielsen, J. (1994). *Usability inspection methods* (pp. 413–414). ACM New York, NY, USA.

Nierling, L., & Domínguez-Rué, E. (2016). *Ageing and Technology: Perspectives From the Social Sciences*. Transcript Verlag

Nigam, Y., Knight, J., Bhattacharya, S., & Bayer, A. (2012). Physiological Changes Associated with Aging and Immobility. *Journal of Aging Research,2012*, 1-2. doi:10.1155/2012/468469

Nyman, S. R., Barker, A., Haines, T., Horton, K., Musselwhite, C., Peeters, G., Wolff, J. K. (2018). *The Palgrave handbook of ageing and physical activity promotion*. Cham, Switzerland: Palgrave Macmillan. doi: https://doi.org/10.1007/978-3-319-71291-8

Olson, K. E., O'Brien, M. A., Rogers, W. A., & Charness, N. (2010). Diffusion of Technology: Frequency of use for Younger and Older Adults. *Ageing International,36*(1), 123-145. doi:10.1007/s12126-010-9077-9

Pak, R., & McLaughlin, A. (2010). *Designing displays for older adults*. Boca Raton, FL: CRC Press.

Pasqualotti, A., Pasqualotti, P. R., Zanin, J. (2007). *Ambientes de interacção, mediação e comunicação: análise dos critérios de usabilidade e acessibilidade no atendimento às expectativas da pessoa idosa*. Centro Universitário Feevale, Novo Hamburgo – RS Brasil. http://www.niee.ufrgs.br/eventos/CIIEE/2007/pdf/CP-309.pdf

Patterson, I. R. (2007). *Growing older: Tourism and leisure behaviour of older adults*. Cambridge, MA: CABI Pub.

Petkov, P., Köbler, F., Foth, M., Medland, R., & Krcmar, H. (2011). Engaging energy saving through motivation-specific social comparison. *Proceedings of the 2011 Annual Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA 11,*1-6. doi:10.1145/1979742.1979855

Pink, D. H. (2018). *Drive: The surprising truth about what motivates us*. Edinburgh: Canongate Books.

Pucher, J., & Buehler, R. (2008). Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. *Transport Reviews,28*(4), 495-528. doi:10.1080/01441640701806612

Quivy, Raymond, & Campenhoudt, Luc Van (2008). Manual de investigação em ciências sociais. [Handook of research in social sciences] Lisboa: Gradiva, 5ªed., ISBN 9789726622758.

Ramadan, F. (2009). Human Aging. *POGOe - Portal of Geriatrics Online Education*; Retrieved from: https://pogoe.org/productid/20016

Rastegaeva, T. E., & Kazakov, I. S. (2016). Tourism – A Social And Economic Phenomenon Of Modern-Day. *Krasnoyarsk Science,0*(1), 107. doi:10.12731/2070-7568-2016-1-107-118

Resende, J. C., & Filho, N. A. (2011). Cicloturistas na Estrada Real: Perfil, forma de viagem e implicações para o segmento. *Revista Turismo Em Análise,22*(1), 168. doi:10.11606/issn.1984-4867.v22i1p168-194

Rezende, L. F. M. de, Rey-López, J. P., Matsudo, V. K. R., & Luiz, O. do C. (2014). *Sedentary behavior and health outcomes among older adults: a systematic review. BMC Public Health, 14(1).* doi:10.1186/1471-2458-14-333

Ribeiro, O., & Paúl, C. (2011). *Manual de envelhecimento activo*. Lisboa: Lidel. ISBN: 978-972-757-739-2

Richey, R. C., & Klein, J. D. (2005). Developmental research methods: Creating knowledge from instructional design and development practice. *Journal of Computing in Higher Education,16*(2), 23-38. doi:10.1007/bf02961473

Riebe, D., Ehrman, J. K., Liguori, G., & Magal, M. (2018). *ACSMs guidelines for exercise testing and prescription*. Philadelphia: Wolters Kluwer.

Rigby, S., & Ryan, R. M. (2011). Glued to games: How video games draw us in and hold us spellbound. *Choice Reviews Online,49*(01). doi:10.5860/choice.49-0099

Rikli, R. E., & Jones, C. J. (2013). *Senior fitness test manual*. Champaign: Human Kinetics.

Robson, K., Plangger, K., Kietzmann, J. H., Mccarthy, I., & Pitt, L. (2015). Is it all a game? Understanding the principles of gamification. *Business Horizons,58*(4), 411-420. doi:10.1016/j.bushor.2015.03.006

Rodriguez, E., & Boks, C. (2005). How design of products affects user behaviour and vice versa: The environmental implications. *2005 4th International Symposium on Environmentally Conscious Design and Inverse Manufacturing*. doi:10.1109/ecodim.2005.1619166

Römer, A., Pache, M., Weißhahn, G., Lindemann, U., & Hacker, W. (2001). Effort-saving product representations in design—results of a questionnaire survey. *Design Studies,22*(6), 473-491. doi:10.1016/s0142-694x(01)00003-5

Rose K. (1994) Unstructured and semi-structured interviewing. *Nurse Researcher* 1, 3, 23-32

Rubin, M. A., & Rowe, P. G. (1990). Design Thinking. *Journal of Architectural Education (1984-),43*(3), 45. doi:10.2307/1425075

Ryan, R. M., & Deci, E. L. (2000a). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology,25*(1), 54-67. doi:10.1006/ceps.1999.1020

Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist,55*(1), 68-78. doi:10.1037//0003-066x.55.1.68

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion,30*(4), 344-360. doi:10.1007/s11031-006-9051-8

Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior,69*, 371-380. doi:10.1016/j.chb.2016.12.033

Salvucci, D. D., & Goldberg, J. H. (2000). Identifying Fixations and Saccades in Eye-tracking Protocols. *Proceedings of the Symposium on Eye Tracking Research & Applications - ETRA 00*. doi:10.1145/355017.355028

Sawyer, B. & Smith, P. (2008). Serious Games Taxonomy. *Presentation, GDC, San Francisco, CA*. Retrieved from http://www.seriousgames.org/presentations/serious-games-taxonomy-2008_web.pdf

Schiessl, M., Duda, S., Thölke, A., & Fischer, R. (2003). Eye tracking and its application in usability and media research. Retrieved from https://pdfs.semanticscholar.org/ecc2/e7752ca4ab5da2bd9078055cf0f02b355f14.pdf. DOAJ

Schuler, D. (2017). Participatory Design. doi:10.1201/9780203744338

Schuler, D., & Namioka, A. (1993). Participatory design: Principles and practices: CRC.

Schütze, M., Sachse, P., & Römer, A. (2003). Support value of sketching in the design process. *Research in Engineering Design,14*(2), 89-97. doi:10.1007/s00163-002-0028-7

Scott-Kemmis, J. (2009). The Color Orange. Retrieved from https://www.empower-yourself-with-color-psychology.com/color-orange.html

Sears, A., & Jacko, J. A. (2008). *The Human-computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*. Boca Raton: CRC Press.

Sebastianelli, A. (2013, December 1). Bike riding: The future of sustainable tourism. Retrieved November, 2018, from https://ecobnb.com/blog/2013/12/bike-riding-sustainable-tourism/

Seidel, M., Loch, C., Chahil, S. (2005). Quo Vadis, Automotiven Industry? A Vision of Possible Industry Transformations. *European Management Journal*, Vol. 23, No. 4, pp. 439–449, 2005

Seligman, M. E. (1996). *Helplessness: On depression, development, and death*. New York, NY: Freeman. doi: https://doi.org/10.1192/S0007125000042616

Shaw, B. A., Krause, N., Liang, J., & Bennett, J. (2007). Tracking changes in social relations throughout late life. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 62(2), S90-S99.

Shephard, R. J. (2002). *Gender, physical activity and aging*. Boca Raton: CRC Press.

Skjæran, M., & Wang, A. I. (2018). Pedal Kart - The creation and evaluation of a cardiovascular exercise bike game. *Norwegian University of Science and Technology*.

Smith, C. & Jenner, P. (1997). "The seniors` travel market", *Travel & Tourism Analyst, Nº 5*, pp. 43 – 62.

Smith, S. T., & Schoene, D. (2012). The use of exercise-based videogames for training and rehabilitation of physical function in older adults: Current practice and guidelines for future research. *Aging Health,8*(3), 243-252. doi:10.2217/ahe.12.30

Spinney, J. (2006). A Place of Sense: A Kinaesthetic Ethnography of Cyclists on Mont Ventoux. *Environment and Planning D: Society and Space,24*(5), 709-732. doi:10.1068/d66j

Strava (2018). Strava: Everything you need to know about the world's leading cycling app. (2018, October 11). Retrieved from https://www.cyclingweekly.com/tag/strava

Streubert, H., & Carpenter, D. (1995). *Qualitative research in nursing: Advancing the humanistic imperative*. Philadelphia: J.B. Lippincott.

Stringer, E. T. (1999). Action research second edition. Thousand Oaks, CA: Sage

Sutton, J. & Austin, Z. (2015). Qualitative Research: Data Collection, Analysis and Management. The Canadian journal of hospital pharmacy, 68(3), 226-31.

Taylor, P. (2007). Editorial: Motives and Motivation... *Art Education, 60*(1), 4-5. Retrieved from http://www.jstor.org/stable/27696186

Taylor, S. J., Bogdan, R., & DeVault, M. L. (2016). *Introduction to qualitative research methods: A guidebook and resource*. Hoboken, NJ: John Wiley & Sons.

Techopedia (2015) What is PICTIVE? - Definition from Techopedia. (2015, August). Retrieved December 5, 2018, from https://www.techopedia.com/definition/16425/pictive

Teixeira, S. (2005). *Gestão das organizações*. Madrid: McGraw-Hill, Interamericana de España.

Terra, I. & Veloso, A. (2014). O "jogo da malha" - *videojogo com paradigma de interação gestual adaptado aos seniores*. Prisma.com – edição especial "Especial O cidadão sénior e as ecologias Web". 23.

Tobii (2015). This is eye tracking. (2015, July 24). Retrieved May, 2019, from https://www.tobii.com/group/about/this-is-eye-tracking/

Torres, A. (2008, November). *Cognitive effects of videogames on older people*. Paper presented at ZON Digital Games 2008, Porto, Portugal.

Tracy, S. K. (2013). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact*. Chichester: Wiley-Blackwell.

Tsukayama, H. (2013, April 18). At Children's Hospital, video games are part of the prescription. Retrieved November, 2018, from https://www.washingtonpost.com/business/technology/at-childrens-hospital-video-games-are-part-of-the-prescription/2013/04/18/f6d8aeb0-a821-11e2-8302-3c7e0ea97057_story.html?noredirect=on&utm_term=.6e55e75fb789

UNWTO Tourism Highlights: 2018 Edition. | World Tourism Organization. (2008) Retrieved from https://www.e-unwto.org/doi/book/10.18111/9789284419876 Print Edition Inquiries

Väänänen-Vainio-Mattila, K., Roto, V., & Hassenzahl, M. (2008). Towards practical user experience evaluation methods. In EL-C. Law (Ed.), *Proceedings of the International Workshop on Meaningful Measures: Valid Useful User Experience Measurement (VUUM), June 18th, 2008, Reykjavik, Iceland* (pp. 19-22)

Vallerand, R. J., Pelletier, L. G., Blais, M. R., Briere, N. M., Senecal, C., & Vallieres, E. F. (1993). On the Assessment of Intrinsic, Extrinsic, and Amotivation in Education: Evidence on the Concurrent

and Construct Validity of the Academic Motivation Scale. *Educational and Psychological Measurement,53*(1), 159-172. doi:10.1177/0013164493053001018

Vance, D. E., Roberson, A. J., Mcguinness, T. M., & Fazeli, P. L. (2010). How Neuroplasticity and Cognitive Reserve Protect Cognitive Functioning. *Journal of Psychosocial Nursing and Mental Health Services,48*(4), 23-30. doi:10.3928/02793695-20100302-01

Vaz Serra, A. (1986). O inventário clínico de auto-conceito. Psiquiatria Clínica, 7(2), 67-84.

Vianna, Y., Vianna, M., Medina, B. & Tanaka, S. (2013) *Gamification, INC.* – Como reinventar empresas a partir de jogos (1ª ed). Brasil: MJV PRESS

Watson, T. W. (1997). Guidelines for Conducting Interviews. *PsycEXTRA Dataset*. doi:10.1037/e592582010-001

Webb, N. (2008). Persuasive games: The expressive power of videogames - By Ian Bogost. *British Journal of Educational Technology,39*(5), 951. doi:10.1111/j.1467-8535.2008.00890_3.x

Werbach, K., & Hunter, D. (2012). *For the win: How Game Thinking Can Revolutionize Your Business*. Philadelphia, USA: Wharton Digital Press.

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review,66*(5), 297-333. doi:10.1037/h0040934

Whitlock, L. A., McLaughlin, A. C., & Allaire, J. C. (2012). Individual differences in response to cognitive training: Using a multi-modal, attentionally demanding gamebased intervention for older adults. Computers in Human Behavior, 28(4), 1091– 1096. doi: https://doi.org/10.1016/j.chb.2012.01.012

WHO (2002). Active Ageing: A Policy Framework. A Contribution of World Health Organization to the Second United Nations World Assembly of Ageing, Madrid, Spain, 2002. doi:10.1080/713604647

Wu, C. (2012). HCI and Eye Tracking Technology for Learning Effect. *Procedia - Social and Behavioral Sciences,64*, 626-632. doi:10.1016/j.sbspro.2012.11.073

Xu, F., Tian, F., Buhalis, D., & Weber, J. (2013). Marketing Tourism via Electronic Games: Understanding the Motivation of Tourist Players. *2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)*. doi:10.1109/vs-games.2013.6624235

Xu, F., Weber, J., & Buhalis, D. (2014). Gamification in Tourism. *Information and Communication Technologies in Tourism 2014,*525-537. doi:10.1007/978-3-319-03973-2_38

Xu, F., Weber, J., & Buhalis, D. (2017). Serious Games and the Gamification in Tourism. *Tourism and Management 2017,60:*244-256. doi: 10.1016/j.tourman.2016.11.020

Zheng, R. Z., Hill, R. D., & Gardner, M. K. (2013). *Engaging older adults with modern technology: Internet use and information access needs*. Hershey, Pa: Information Science Reference.

Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps*. Sebastopol, CA 95472: OReilly Media.

Zwift (2018). *What do I need to start Riding in Zwift?* Retrieved October, 2018 from https://support.zwift.com/en_us/what-do-i-need-to-start-riding-in-zwift-B18y0kZB7

This page is left intentionally blank

Appendix

On the enclosed CD-ROM, the interview protocol, the materials and presentations used in the focus group sessions, the participants' answers, the eye-tracking data, the NVivo results and high-quality images of the prototype of the cyclo-tourism app *Jizo* are included.

Any questions feel free to contact me (claudiaortet@ua.pt).

Three directories are included in the root directory:

- CV > *Curriculum Vitae;*
- Materials > Interview protocol, materials and presentations, the participants' answers, the eye-tracking data, the NVivo results, the app demo and high-quality images;
- Scientific Articles > A copy of the articles or abstracts produced with this Master's dissertation.